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WATER RESOURCE PROBLEMS RELATED TO MINING IN THE BLACKBIRD MINING DISTRICT, IDAHO

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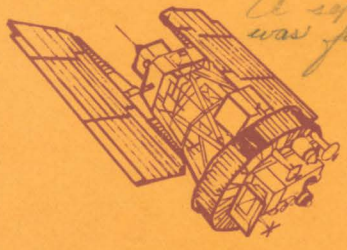

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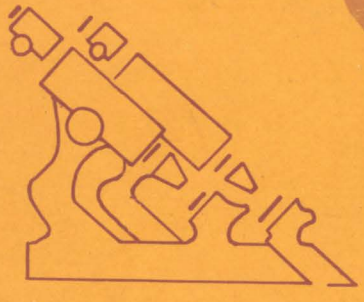

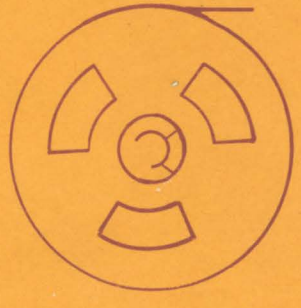

by

Joe A. Baldwin
Dale R. Ralston
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COLLEGE OF MINES
University of Idaho
Moscow, Idaho 83843

Completion Report

for

Supplements 35 and 48

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by

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February, 1978

ABSTRACT

The Blackbird Mining District is located in east-central Idaho near Salmon, Idaho. The Blackbird Mine is the principal mine in the district. Metal deposits in the form of cobalt, and copper sulphides have been mined and milled at the Blackbird Mine since 1917. Pyrite (iron sulphide) associated with these metal deposits has been exposed to air and water and has subsequently oxidized to yield acidity (H^+), sulphate, and ferrous iron to the water. Additional metal ions are leached from low grade ore and waste rock by the acidic mine drainage.

University of Idaho investigators established surface water and mine drainage sampling stations to monitor water quality and quantity in the mining area. Field observations of pH, electrical conductivity, and temperature were recorded and concentrations of seven metal ions were determined in the laboratory using an atomic absorption spectrophotometer. Data collected by mining company personnel during the period 1967-71 were also evaluated during the course of this study.

Blackbird and Bucktail Creeks drain the mining area. Discharge from the Blackbird Creek drainage at station 4 (drainage area of 8.6 mi^2) was 5,800 acre-feet for the 1976 water year. Stream discharge from the Blackbird Creek drainage (station 4) contained 7.5, 13.4, and 15.2 tons of dissolved cobalt, copper, and iron respectively for the 1976 water year. Mass balance determinations indicate that about 90 percent of the metal load in Blackbird Creek comes from a small tributary stream and a discharging mine portal. Discharge from the Bucktail Creek drainage at station 23 (drainage area of 0.51 mi^2) was 97 acre-feet for the period January 1 through December 31, 1976. Dissolved metal loads for the same period were

4.9, 17.5, and less than 0.5 tons of cobalt, copper, and iron respectively. Most of this metal load is contributed by springs discharging from waste piles in the stream drainage.

Availability of water to transport oxidation products and physical location of surface waste features are two variables which may be managed to reduce acid drainage from the mining area. Segregation of acid drainage from good quality water would greatly reduce the volume of poor quality water requiring treatment, and reclamation procedures applied to existing mine features could further reduce acid contributions. Future mining operations should be accompanied by reclamation plans designed to lessen the impacts of mining.

ACKNOWLEDGEMENTS

This research was conducted by the University of Idaho in cooperation with the Idaho Bureau of Mines and Geology, the U.S.D.A. Forest Service, the Hanna Mining Company and the Idaho Mining Company. The effort was partially supported by a research cooperative agreement with the Surface Environment and Mining (SEAM) section of the Forest Service administered through the Intermountain Forest and Range Experiment Station.

A number of individuals contributed to the final product from this research effort in addition to those listed as authors. Dennis Williams, a former student at the University of Idaho, worked on the project during the early stages of study. Drs. Roy E. Williams and Myron Molnau, both of the University of Idaho, provided technical advice to the investigators and reviewed the completion report. Roman S. Popielak, formerly with the Idaho Bureau of Mines and Geology, provided major field support in well drilling during the project. Eugene Farmer, Intermountain Forest and Range Experiment Station, U.S.D.A. Forest Service, provided technical and financial advice and assistance as contract officer for the project. Bland Richardson, also with the Experiment Station, provided a water truck used during the installation of piezometers in the study area.

Special thanks go to Robert S. Aikens, Vice-President, Engineering, and Jack A. McAulliffe, mine supervisor, both of Hanna Mining Company for the information and assistance they provided. Jack "Bus" Miller, mine superintendent and others from the Idaho Mining Company provided invaluable assistance during the field seasons. The Idaho Mining Company provided housing for all field personnel throughout the course of this study.

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CHAPTER I

INTRODUCTION

General Statement

In October, 1972, the 92nd Congress of the United States passed the Federal Water Pollution Control Act Amendments of 1972. The purpose of this legislation was to give more weight to earlier legislation in the areas of protection and maintainance of the quality of the environment. Designated Public Law 92-500 (PL 92-500), the amendments apply to the mining, milling, and metallurgical industries by way of Sections 301, 302, and 304, under Title III - "Standards and Enforcement, Effluent Limitations". These sections state that by July 1, 1977, the best practicable control technology currently available must be applied to waste effluent, and that by July 1, 1983, the best available technology economically achievable must be applied to waste effluent.

The metal mining industry has historically been a source of poor quality water. Effluent produced by the industry is often low pH in nature and high in dissolved solids. In many instances this water was discharged directly into nearby streams with no treatment to remove dissolved metals or suspended solids. With the implementation of such acts as PL 92-500, operating mines have constructed tailings ponds and installed water treatment facilities to meet effluent guidelines. However, some mines which have been abandoned or closed prior to adoption of effluent guidelines continue to discharge poor quality water to surrounding streams.

Numerous examples of this situation exist in metal mining areas of the northwestern United States. Sceva (1973) noted areas in Oregon, Idaho, and

Washington where inactive mines contribute dissolved metals such as iron, manganese, copper, and zinc to nearby drainages. High concentrations of dissolved iron and aluminum pose a major water quality problem in the vicinity of Cooke City, Montana, where two inactive gold mines are located (Sonderegger and others, 1975). Poor quality water discharging from one of the mining areas drains into nearby Yellowstone National Park. Twenty-five areas in Colorado affected by acid mine drainage have discharges high in iron and sulphate as well as other trace elements (Wentz, 1974; Moran and Wentz, 1974).

This study deals with water resource problems of the Blackbird Mining District in east-central Idaho. The Blackbird Mining District borders the scenic Big Horn Crags Recreational Area on the south and lies east of the Cental Idaho Primitive Area. Discharge high in dissolved metals and low-pH in nature originates from the inactive Blackbird Mine, the principal mining site in the district. Poor quality water discharging from the copper-cobalt mining area flows into Panther Creek, a tributary to the Salmon River. The Salmon River has been designated a Wild and Scenic River by the Congress of the United States. This study was initiated June, 1974, by University of Idaho personnel with funding from the Surface Environment and Mining program of the USDA, Forest Service. The Idaho Bureau of Mines and Geology (IBMG) provided field vehicles throughout the course of the field study.

Purpose and Objectives

The study was conducted to provide the mining company and the Forest Service with an analysis of alternatives for reduction or elimination of water quality problems in the Blackbird Mining District. The objectives

of the study were to delineate alternatives for water quality control with respect to mine related features of the Blackbird Mine, and to evaluate and recommend techniques to minimize water quality problems in future mining activities in the district.

The specific objectives of the study were to:

i. Determine the relationship between ground-water recharge, movement, and discharge, and acid production in underground workings and surface waste features in the mining area.

ii. Determine the relationship between surface and ground-water quality for surface waste features and stream drainages.

iii. Determine the relative contributions of poor quality water from the various sources in the mining area by a quantitative analysis of flow and metal loads.

iv. Recommend procedures for reducing acid production from present surface and underground mining features, and recommend solutions to potential problems of acid production from future mining operations.

Description of the Blackbird Mining District

Location

The Blackbird Mining District is located approximately 25 miles west of Salmon, Idaho, and lies within the U. S. Geological Survey's Blackbird Mountain 1:62,500 quadrangle (Figure I-1). The Blackbird Mine is located at longitude 114°20', latitude 45°02' within the quadrangle. The mining area is drained by Blackbird and Bucktail Creeks, both tributary to Panther Creek in the Salmon River drainage. The Panther Creek drainage basin includes Blackbird Creek which drains an area of about 23 square miles and Bucktail Creek which drains an area of about 1.7 square miles.

The townsite of Cobalt is located on Panther Creek approximately ten miles east of the Blackbird Mine. The Hanna Mining Company, through the

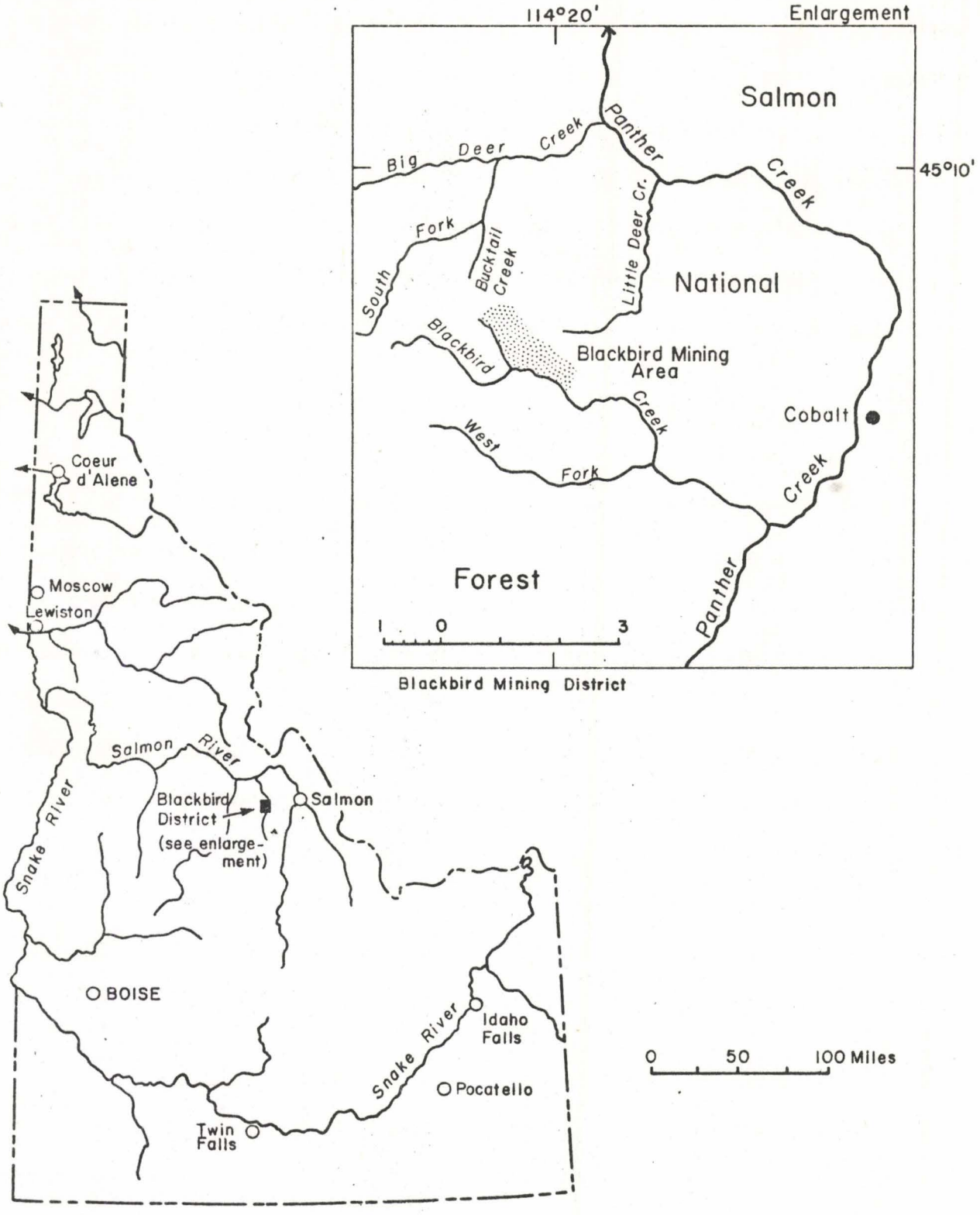


Figure I-1. Map of Idaho showing location of the Blackbird Disrtict and the Blackbird Mining area.

Idaho Mining Company, owns the townsite and is a full-lease holder of the Blackbird claims. Ten to fifteen people maintain a year-round residence at Cobalt.

Cobalt and the Blackbird Mining District may be reached by three gravel surfaced roads from U. S. Highway 93; from the south via Challis over the Morgan Creek Summit, from the east from Salmon over the Williams Creek Summit, and from the north up Panther Creek via Shoup. The route east from Salmon is maintained throughout the year while the other two routes are maintained only during the summer months.

Geomorphology

The topographic expression in the district is one of rugged relief. Elevations range from 4,000 feet above sea level in the valleys to over 9,000 feet above sea level on the mountain peaks. The geomorphic development is in the youthful stage exhibiting broad flat topped mountains, steep canyon walls, and very narrow valley floors. Drainage and stream patterns appear to be fault controlled.

Climate and Vegetation

Climate of the Blackbird Mining District is continental with considerable influence from east moving maritime air masses. Consequently, most precipitation events are due to thunderstorm activity in the summer and large storm cells during the winter months. Most of the annual precipitation occurs during the winter months in the form of snow. Average snow depths on March 31 for the period 1968 to 1975 were 50 inches on the Morgan Creek Summit snow course and 49 inches on the Williams Creek Summit snow course. Average water content on March 31 for the same eight year period was 16.1 inches for the Morgan

Creek Summit and 14.9 inches for the Williams Creek Summit.

Precipitation data are available at the Cobalt townsite from 1961 to 1976. These data are presented in Table I-1. Two storage type precipitation gages were installed in the study area in October, 1974, following procedures outlined by Trihey (1974). Precipitation gage one was installed near the mill at an elevation of 6905 feet. This gage was located on a south facing slope. Precipitation gage two was installed near the Bucktail Pit at an elevation of 7885 feet. This gage was located on an east facing slope.

Precipitation from October 1, 1974, to September 30, 1975, was 24.6 inches for gage one and 23.4 inches for gage two. Precipitation for the same period was 19.9 inches at Cobalt. During the 1975-76 water year, precipitation at gages one and two was 28.5 and 29.6 inches respectively. Precipitation at Cobalt for this period was 22.5 inches. As expected, precipitation is greater at the higher elevations in the Blackbird Creek drainage than at the Cobalt townsite.

Vegetation in the district is controlled by climate and elevation. North and south facing slopes also play a dominant role in vegetation types and distribution. Douglas-fir dominates on the upper south facing slopes with scattered Lodgepole Pine and Subalpine Fir. Douglas-fir and Englemann Spruce predominate on the lower north facing slopes with Lodgepole Pine and Subalpine Fir dominant in the higher areas. Valley bottons are covered with a variety of Englemann Spruce, Douglas-fir, Ponderosa Pine, willows, sagebrush, mountain mahogany, bunch grass and various shrubs.

Table I-1. Total monthly precipitation in inches at Cobalt, Idaho, for the period January 1961 through December 1977.

	October	November	December	January	February	March	April	May	June	July	August	September	Annual
61-62				0.47	1.66E	0.49-	0.68	2.80	1.84-	1.33	0.91	0.07-	
62-63	1.42	2.04-	1.62	0.65-	2.59	0.79	3.17	1.36	5.21	0.62	0.35	1.11-	
63-64	2.61	1.69	0.73	2.54-	0.71	0.77	3.36				0.97	0.49	
64-65	0.29			2.56	0.29	0.10							
65-66	0.00-	1.03	1.01	1.44	1.39					0.00-	0.76	1.63	
66-67	0.78	0.88	0.99	1.69	0.61	1.89	3.36	0.93	2.91	1.65	0.24	1.48	17.41
67-68	2.98	0.47	0.99	0.72	1.69	0.86	1.07	1.42	2.29	1.99	3.34	2.48	20.30
68-69	0.76	3.24	1.27	2.58	0.39	0.63	1.09	0.99	2.52	1.76	0.13	0.68	16.04
69-70	0.99	0.64	1.52	2.75	0.40	1.85	1.08	1.65	3.42	1.35	0.49	2.68	18.82
70-71	1.76	2.06	1.50	3.33	1.10	1.70	3.25	2.54	1.56*	0.88	0.77	0.68	21.13
71-72	1.02	1.65	2.78	2.21	1.77	2.03	1.30	1.01	2.12	0.67	1.61	1.65	19.82
72-73	0.84	1.08	1.19	0.91	0.05	0.91	1.34	0.72	2.00	0.93	0.97	2.58	13.52
73-74	0.92	2.85	2.23	1.89E	0.83	2.89	0.59	1.63	0.43	0.74	1.45	0.18	16.63
74-75	0.75	0.87	1.17	3.26	1.02	1.18	2.65	1.88	1.65	3.30	1.80	0.32	19.85
75-76	3.20	1.32	2.80	2.20	1.61	1.24	1.83	1.56	1.77	1.07	2.00	1.90	22.50
76-77	0.33	0.34	0.29										
Mean	1.33	1.39	1.44	2.00	1.07	1.30	1.91	1.54	2.35	1.36	1.13	1.40	
No. of Months	14	13	14	13	15	13	13	12	11	12	14	12	
Percent Annual	7.3	7.6	7.9	11.0	5.9	7.1	10.5	8.5	12.9	7.5	6.2	7.7	

Mean Annual Precipation 18.22 inches.

- missing values during month
E estimated values during month
* accumulations during month

Land Use

Mining and logging have played the major land use roles in the Blackbird Mining District. Mines have operated intermittently from the early 1900's to the late 1960's. The support population center during this time was the village of Colbalt. Logging operations are ongoing at various locations in the district at the present time.

At the present, the recreational value of the area is considerable. The mining area borders the Bighorn Crags Recreational Area on the south and the Idaho Primitive Area on the west. Increased demand is being felt throughout the area for the support of hunting, fishing, camping, and hiking activities.

Hydrology

Stream flow in the district is typical of the variable flow of mountainous regions. Runoff is high during the spring snowmelt season dropping to very low values during the late summer and fall. Flooding of the stream bank and channel will occur and the potential for stream scour is high during runoff. As a consequence, sediments from tailings and waste piles in the mining area are transported downstream and are redeposited on the flood plains and channels of lower Blackbird Creek and Panther Creek.

Geology of the Blackbird Mining District

The geology of the Blackbird Mining District is dominated by Precambrian metamorphic rocks of the Belt series (Anderson, 1947). South of the district, these impure quartzites are overlain by Tertiary age Challis Volcanic rocks while they form discordant contacts with granitic intrusive rocks contemporary with the Idaho Batholith in the north. Border

facies between the metamorphic and intrusive rocks are common to the area. These metamorphic rocks have a regional scale folding system striking east-west with moderate dips to the north and east (Anderson, 1947, p.26).

Belt Rocks

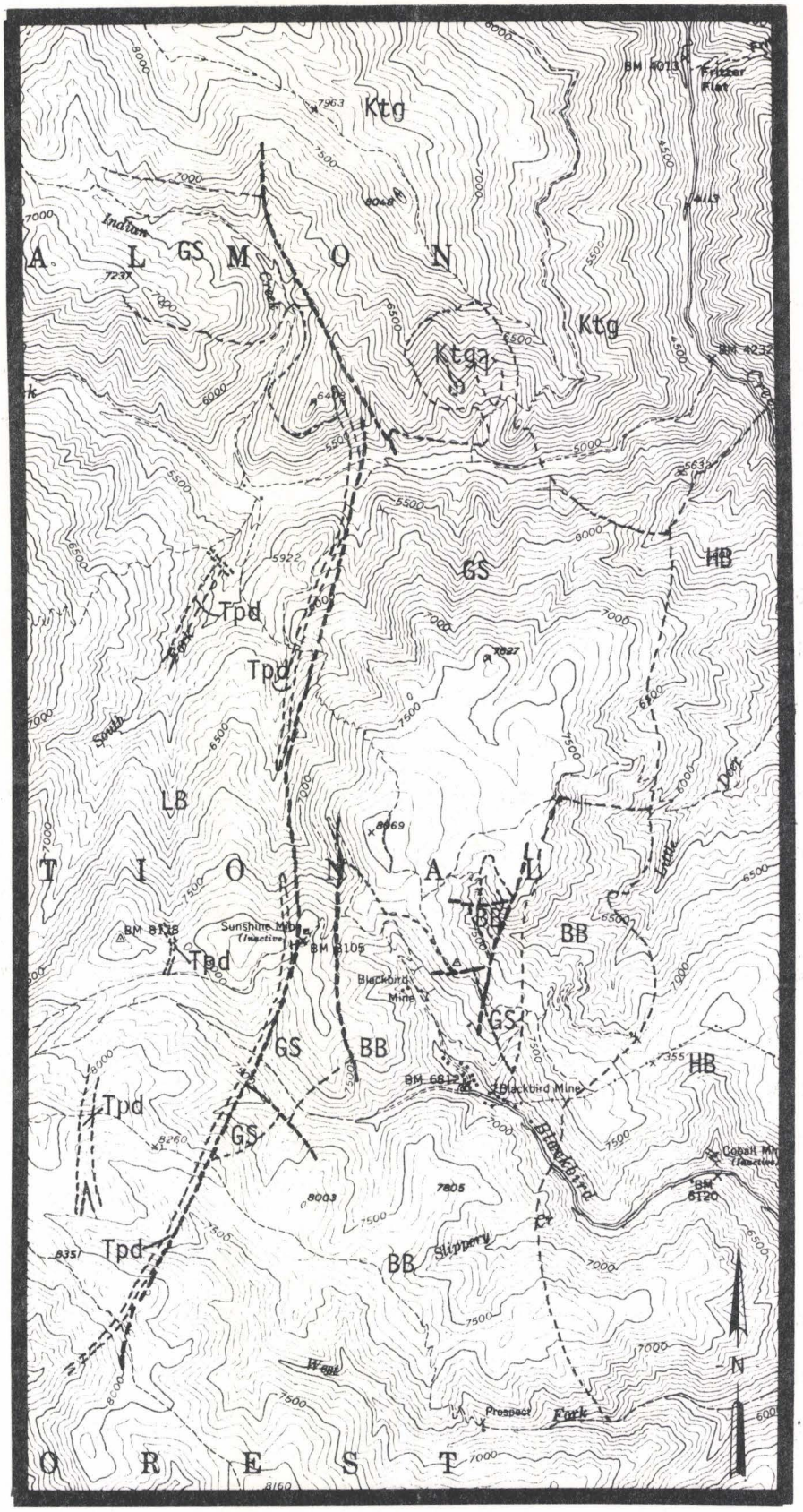
The Precambrian metamorphic rocks of the Belt series have been derived primarily from thinly bedded argillaceous quartz sands. Ripple marks, cross bedding, and mud cracks suggest the existance of a shallow sea. Various degrees of regional and contact metamorphism have altered the original sediment to thick sequences of recrystallized quartz and biotite micas. Garnets, chlorite, and feldspathic enrichment of border rocks are present in the contact zones with the Cretaceous intrusive rocks. The Belt series rocks in the Blackbird area have been subdivided into four reasonably distinct structural units based on composition, schistosity, and color (Umpleby, 1913; and Vhay, 1948). The oldest unit is the Blackbird, overlain by the Lookout, the West Fork and the youngest, the Haynes Stellite (Table I-2). All four units are believed to be correlative with the Yellowjacket formation of Belt age (Vhay, 1948, p. 2). All of the units contain traces of cobalt and copper mineralization; however, the Blackbird unit is the richest and most developed. Figure I-2 is a general geologic map of the Blackbird District from Vhay (1948).

Structure

Structure in the Blackbird Mining District is dominated by several open north plunging major folds with associated drag structures. Superimposed on the large folds are smaller scale folding features of generally the same orientation. Northwest trending joint and fault systems have provided ample

Table I-2. Generalized section of Belt series rocks, Blackbird Mining District, Idaho (from Umpleby, 1913, and Vhay, 1948).

Structural Unit	Lithology
Haynes Stellite	Very thick, massive, dark gray, finely bedded quartzite. Shistocity poorly developed. Fine grained cobalt mineralization with tourmaline.
West Fork	Light colored, thinly bedded subquartzite. Little mineralization.
Lookout	Dark grey, well bedded, shistose and non-shistose biotite quartizite. Minor cobalt-copper mineralization.
Blackbird	Dark grey-black, highly shistose biotite quartzite. Major cobalt-copper mineral associations.



Tpd Porphyry dikes/sills

Ktg Idaho batholith

GS Garnet schist

LB Lookout structural block

BB Blackbird structural block

HB Haynes-Stellite structural block

---- Contact

----Fault

Figure I-2. General geologic map of the Blackbird District from Vhay(1948).

avenues for the emplacement of the ore deposits with post ore shearing contributing to the complexity of the mining situation.

Location and Character of the Mine

Location

The headquarters and mill for the Blackbird Mine are located on Blackbird Creek at its confluence with Meadow Creek (Figure I-3). Levels of most recent mining are located above the main complex from a main mining level at an elevation of 6850 feet to the open pit operation located at 7800 feet. Mining extends below the open pit into the Bucktail Creek drainage. Access to the Blackbird Mine operations is by a gravel road that follows Blackbird Creek from the Panther Creek road.

History

Noteworthy mineralization in the district was first reported in 1893 by miners from nearby Leesburg. Many small deposits were prospected and consolidated by the Blackbird Copper-Gold Mining Company from 1893 to 1907 but no economic returns were realized. About 4,000 tons of ore was mined and milled from 1917 to 1920 by the Haynes-Stellite Company. Concentrates shipped contained about 18 per cent cobalt (Vhay, 1948, p. 1). Activity slowed until about 1938 when the Uncle Sam Mining Company reopened two old tunnels and built a 75 ton flotation mill. During the period of 1938 to 1941, 461 ounces of gold, 332 ounces of silver, and 163,485 pounds of copper were produced from the area (Vhay, 1498, p. 1). This venture was financially unsuccessful.

The United States Government conducted exploration in the district in the early 1940's in search of a domestic source of cobalt. In response to this exploration program, the Calera Mining Company became interested

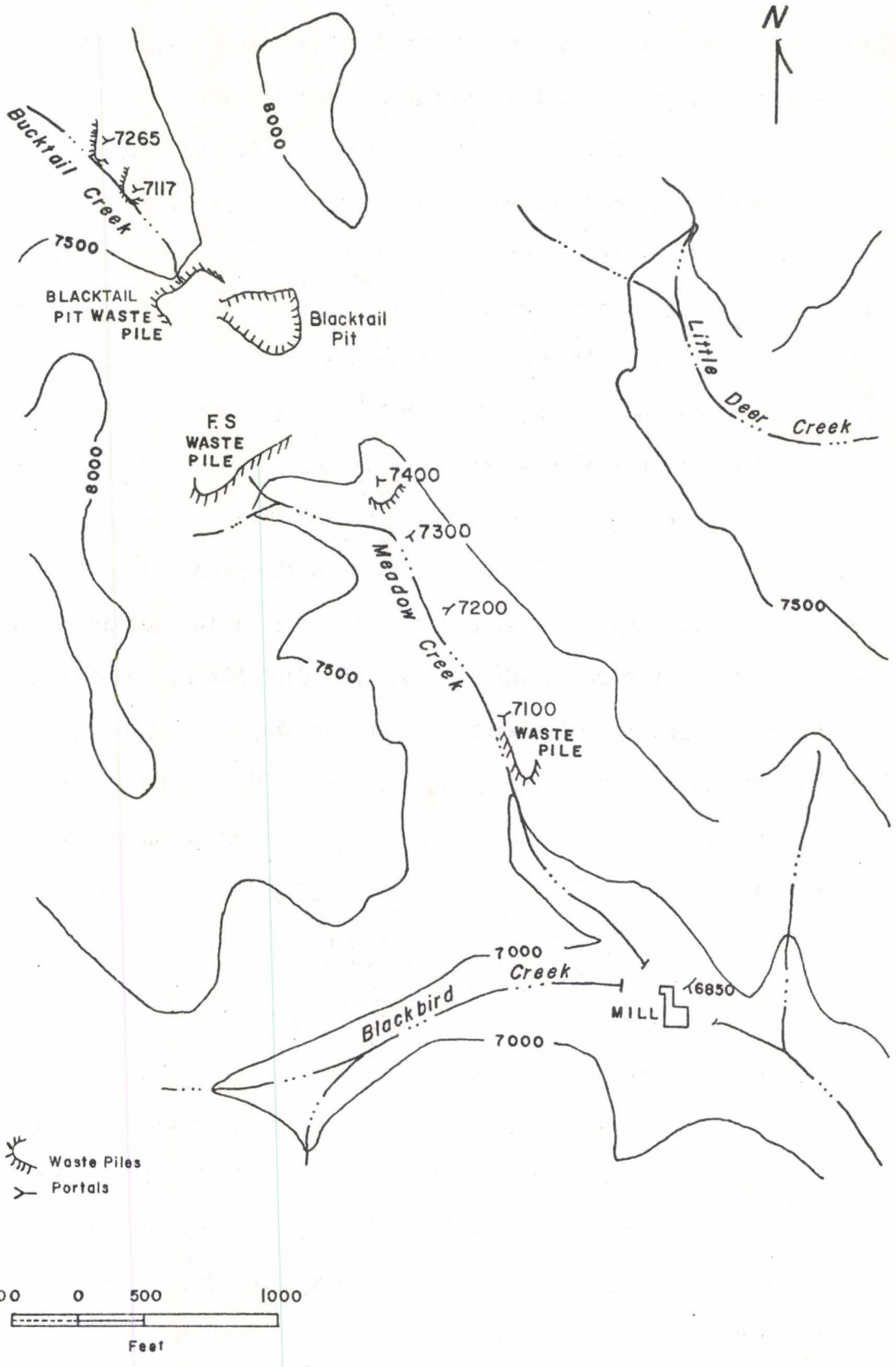


Figure I-3. Blackbird Mine facilities.

in the property in 1943. The results of a drilling program at that time were promising enough to justify underground exploration. The amount of ore developed by this exploration was considered sufficient to justify a full scale mining operation, which was implemented in 1949.

With the onset of the Korean War, interest was stimulated in the United States in the production of cobalt, and the Calera Mining Company expanded its production plant at the request of the U. S. Government in 1951. The area reached its peak production in 1958. The demand for cobalt decreased after the termination of a Government contract on the metal in 1959. Calera sold its interest to Machinery Center Company in 1959, who in turn sold controlling interests in the property in 1967 to the Idaho Mining Company, a subsidary of the Hanna Mining Company. All production operations stopped in 1967 and the Idaho Mining Company has been engaged in a program of exploration on the property. Production of metals from the Blackbird Mine included some 14 million pounds of cobalt from 1951 through 1959 (U. S. Cong., 1964, p. 66), and about 63 million pounds of copper to 1952 (Vhay, 1952).

Mine Workings and Methods

The Blackbird Mine complex consists of 12 levels, 8 portals, an open pit, 3 major waste piles, a tailings pile, a mill and concentrator, and support facilities. The principal entrance to the mine is at 6850 feet of elevation, marked on various maps as the 6850' level (Figure I-3). This level opens to the main yard which contains the crusher bin, shops, offices, concentrator, etc. This level extends about 9600 feet into the mountain. About 2,200,000 tons of ore have been mined above this level including 758,000 tons from the open pit mine (Davis, 1972, p. 33). No

ore has been mined below this level, although there is a winze to the 6600' level. Above the 6850' level on the south side of the mountain are the 7100', 7200', 7300', and 7400' levels. The St. Joe Shaft is between the 6850' and the 7100' portals. Two portals on the northern side of the mountain are situated below the existing open pit mine. These are the 7117' and the 7265' levels. The 6850' level passes beneath these two levels and continues to the northwest some 1200 feet.

Mining in the underground portion of the mine occurred from drifts following the lenticular and tabular ore bodies. As a result, much of the rock mined in drifting was of mill grade and waste rock was reduced to a minimum. Ore bodies were removed by room and pillar methods and block caving of overhead stopes. Sand fill recovered from the coarse fraction of the milling operation was returned to the mined areas to provide support for continued mining operations or to support abandoned areas. Backfill with tailings was not practiced between the years 1960 to 1967. The movement of equipment, personnel, ore, and waste rock between different levels in the mine was conducted through vertical openings, manways, and ore passes to the main work levels. Plates IA and IB show cross sectional and plan views of the Blackbird Mine workings. The mining operation in the open pit area removed a large volume of rock from an extensive ore zone and created a depression of 11 acres. Waste rock from this operation was dumped into two waste piles (Figure I-3).

Future plans call for the opening of some underground workings and two new open pit operations. The tentative plan is to mine about one-half of the underground ore by an ore-fill-and-shrink method and the other half by the untimbered cut-and-fill method. The mined openings will be filled

with mill tailings after the ore has been extracted, and no further openings to the surface are contemplated for the underground mining operation.

Previous Investigations

Panther Creek and tributary streams sustained sizeable runs of salmon and steelhead prior to major development of the Blackbird Mine in 1945 (Corley, 1967, p. 3). Mill tailings and acid discharge into Blackbird Creek occurred with expansion of mining activities and an immediate decline in the numbers of fish in Panther Creek was noted. The decreasing quality of the aquatic environment prompted several investigations of the area in the late 1960's and early 1970's.

The Idaho Fish and Game Commission initiated the first water quality study in the area. Corley (1967, p. 14) noted that no salmon redds (spawning beds) had been noted in Panther Creek in the five years prior to November, 1967, and that toxic materials originating from the Blackbird Mining area were responsible for the elimination of anadromous fish. Platts (1967, 1968, and 1969) carried out aquatic habitat studies which demonstrated that mining and milling activities in the Blackbird Mining area had damaged the aquatic habitat of streams receiving mining effluent.

Water samples collected by Idaho Mining Company personnel during 1969 were analyzed for dissolved cobalt, copper, and iron, and pH values were recorded for all samples collected (McAuliffe, 1975, written communication). The Idaho Department of Health, Idaho Mining Company, and USDA-Forest Service performed analyses of water samples collected from the mining area during 1971 (Jack McAuliffe, 1975, written communication). Farmer and others (1976) presented results of two years of revegetation research work on one of the major waste piles in the mining area. This

research shows that vegetation can be established on acidic mine waste material if the material is covered with at least 8 inches of native topsoil which has been heavily fertilized.

The Acid Mine Drainage Problem

Water quality problems have long plagued the mining industry. One of the most common mining related water resource problems is the production of acid mine drainage. As early as 1628, references to acid mine drainage were made relative to the coal mining industry (Hawley, 1972). The following statement referred to a coal region in North America (Hawley, 1972, p. 5):

> "I have reason to believe (that) there are good coals (here) also for I have observ'd (that) the runs of water have the same color as that which proceeds from the coal mines in Wales."

Modern-day acid mine drainage has been noted and studied in coal mines in the eastern U. S. for many years (Ohio State University Foundation, 1971). Analysis of acid mine drainage problems of western hard rock mines are not so common to the literature. Mines of this type produce poor quality water which has a low pH and contains a variety of metal irons. The chemistry of acid mine drainage and conditions favorable to the production of poor quality water are well established.

Production of acid water is common to mining situations where pyrite and other metal-sulphides become exposed to atmospheric conditions. Upon exposure to the atmosphere, sufficient oxygen and water are present to initiate the cycle. The oxidation of pyrite occurs according to the following process (Stumm and Morgan, 1970, p. 540-542):

$$FeS_{2(s)} + 7/2\ O_2 + H_2O \rightleftharpoons Fe^{++} + 2SO_4^{=} + 2H^{+} \qquad (1)$$

Although the initial oxidation of pyrite may take place in a dry environment,

$$FeS_{2(s)} + 3\ O_2 \longrightarrow FeSO_4 + SO_2,$$

there is sufficient moisture in waste piles and mine workings to favor reaction (1). The ferrous iron from reaction (1) is oxidized to ferric iron by:

$$Fe^{++} + 1/4\ O_2 + H^+ \rightleftharpoons Fe^{3+} + 1/2H_2O \qquad (2)$$

Hydrolysis of the ferric ion produces ferric hydroxide and releases additional acidity:

$$Fe^{3+} + 3H_2O \rightleftharpoons Fe(OH)_3\downarrow + 3H^+ \qquad (3)$$

The pale-yellow to orange precipitate formed is known as "yellow boy" among miners. This insoluble precipitate coats stream bottoms and forms thick sludges in adits.

The sum of reactions 1, 2, and 3

$$FeS_{2(s)} + 15/4\ O_2 + 7/2H_2O \rightleftharpoons Fe(OH)_3\downarrow + 2SO_4^{=} + 4H^+ \qquad (4)$$

shows that 4 moles of H^+ are released for each mole of FeS_2 oxidized; few other natural weathering reactions produce this amount of acidity.

Various studies (Smith, 1971; Singer and Stumm, 1970) on the importance of ferric iron in the oxidation of FeS_2 have shown that this reaction accounts for the principle method of breakdown of the pyrite:

$$FeS_{2(s)} + 14Fe^{3+} + 8H_2O \rightleftharpoons 15\ Fe^{++} + 2SO_4^{=} + 16\ H^+ \qquad (5)$$

When ferric iron is the oxidizing agent, reaction 2 and 4 determine the rate of oxidation of FeS_2. Reaction (2), the oxidation of ferrous to ferric iron appears to be the rate determining step. The rate of this

reaction is a function of hydrogen ion concentration, decreasing with pH down to about 4.5. From pH 4.5 to 3.5 the relationship of Fe^{++} and O_2 concentration changes and below pH of 3.5 reaction (2) is very slow and independent of pH.

At pH of 3.5 or less, bacteria such as Ferrobacillus ferrooxidans F. Sulfooxidans, and Thiobacillus ferrooxidans accelerate the rate of conversion of Fe^{++} to Fe^{3+}. Singer and Strumm (1970, p. 1122) note such bacteria may accelerate reaction (2) by a factor of 10^6 or more. Walsh and Mitchell (1972) have postulated that bacteria of the genus Metallogenium catalyze ferrous iron oxidation from pH 4.5 to 3.5. Optimum pH for this genus of iron bacteria is 4.1.

Wentz (1974, p. 20) describes the above reactions for a situation where oxygen laden water at a near neutral pH infiltrates mine waste containing pyritic material:

> "The FeS_2 is oxidized, probably by molecular O_2 at first (reaction 1), thus releasing Fe^{++} and lowering the pH. In addition large amounts of SO_4 are produced. Some of the Fe^{++} is oxidized abiotically to Fe^{3+} (reaction 2) which in turn also oxidizes FeS_2 (reaction 4). As the pH and the amount of available O_2 decrease, reaction 1 becomes less important. Moreover, the abiotic rate of reaction 2 also decreases, thus limiting oxidation of FeS_2 by Fe^{3+}. However, at this point (about pH 4.5-5) the iron bacterium *Metallogenium* becomes important and catalyzes reaction 2 until a pH of about 3-3.5 is reached. Below this value, the *Ferrobacillus-Thiobacillus* group takes over the catalysis. It is these later organisms which are responsible for the pH's of less than 3 seen in nature. And, because of the inefficient nature of the Fe^{++} to Fe^{3+} oxidation, these organisms also contribute to the disposition of large amounts of $Fe(OH)_3$ (reaction 3)."

In addition to the formation of water with low pH and high iron, acid produced from the oxidation of pyrite may also dissolve other minerals

which by themselves do not contribute to the formation of acid waters. The disolution of the sulphide copper mineral chalcopyrite is an example (Davis, 1972, p. 8):

$$CuFeS_2 + 2\ Fe_2(SO_4), + 2H_2O + 3\ O_2 \rightleftharpoons CuSO_4 + 5FeSO_4 + 2H_2SO_4 \qquad (6)$$

CHAPTER II

DATA COLLECTION PROGRAM

Introduction

Initial studies in the Blackbird Mining area pointed out the serious nature of the water resource problems and the impacts on aquatic habitats in the mining area as well as downstream areas. These studies indicated the need for better definition of the problem as a first step towards reduction of acid production in the mining area. Definition of acid production areas required water quality and quantity monitoring at selected sites. Collection and analysis of water samples from the Blackbird Mining area began in 1967. Data collection for this study was initiated in 1974. Various agencies and numerous personnel have been involved in sampling and analysis of the more than 2000 samples collected in the area to date (1977).

Previous Data Collection

1967 and 1968 Data Collection

Following the initial aquatic habitat study by Pense (1965) the U.S. Forest Service initiated a data collection program in the Blackbird Mining area (Platts, 1967). Twenty-five sample stations were established in the mine area along Panther Creek (Table II-1 and Figure II-1). Water quality samples were collected at these stations during 1967 and 1968 by Forest Service personnel. Discharge measurements were not taken during this data collection program. Concentrations of 16 anions and cations were determined, and pH, total solids, alkalinity, and hardness data were collected for various samples during the two year period. A large part of the sample

Table II-1. Location and station number of water quality sample stations established in the Panther Creek study area, 1967. Numbers in parenthesis are corresponding University of Idaho sampling stations, shown on Figures II-2 and II-3. All other stations are shown on Figure II-1. (Modified from Platts, 1967).

Sampling Station	Station Location
1B (8)	Blackbird Creek - Above mill
2B (6)	Blackbird Creek - Below mill
3B (3)	West Fork Blackbird Creek - Above tailings pile
4B (2)	West Fork Blackbird Creek - Below tailings pile
5B	Blackbird Creek - Mouth of Blackbird Creek
6B	Panther Creek - Above confluence Fawn Creek
7B	Panther Creek - Above confluence Blackbird Creek
8B	Slippery Creek - Above confluence Blackbird Creek
9B	Ludwig Creek - Above confluence Blackbird Creek
10B (7)	Blackbird Creek - Mine discharge water - 6850 portal
11B	Meadow Creek - Immediately above mill
1P	Panther Creek - Below confluence Moyer Creek
2P	Cooper Creek - Above confluence Panther Creek
3P	Panther Creek - Above confluence Napias Creek
4P	Panther Creek - Above confluence Little Deer Creek
5P	Little Deer Creek - Above confluence Panther Creek
6P	Big Deer Creek - Above confluence Panther Creek
7P	Panther Creek - Rams Point Campground
8P	Panther Creek - Above confluence Salmon River
9P	Salmon River - Above confluence Panther Creek
10P	Panther Creek - Above confluence Big Deer Creek
11P	Panther Creek - Below confluence Big Deer Creek
1M (10A)	Meadow Creek - Between St. Joe portal and Blackbird Creek
2M (13)	Meadow Creek - 1½ miles upstream from mouth
3M (16)	Meadow Creek - Above mining activity

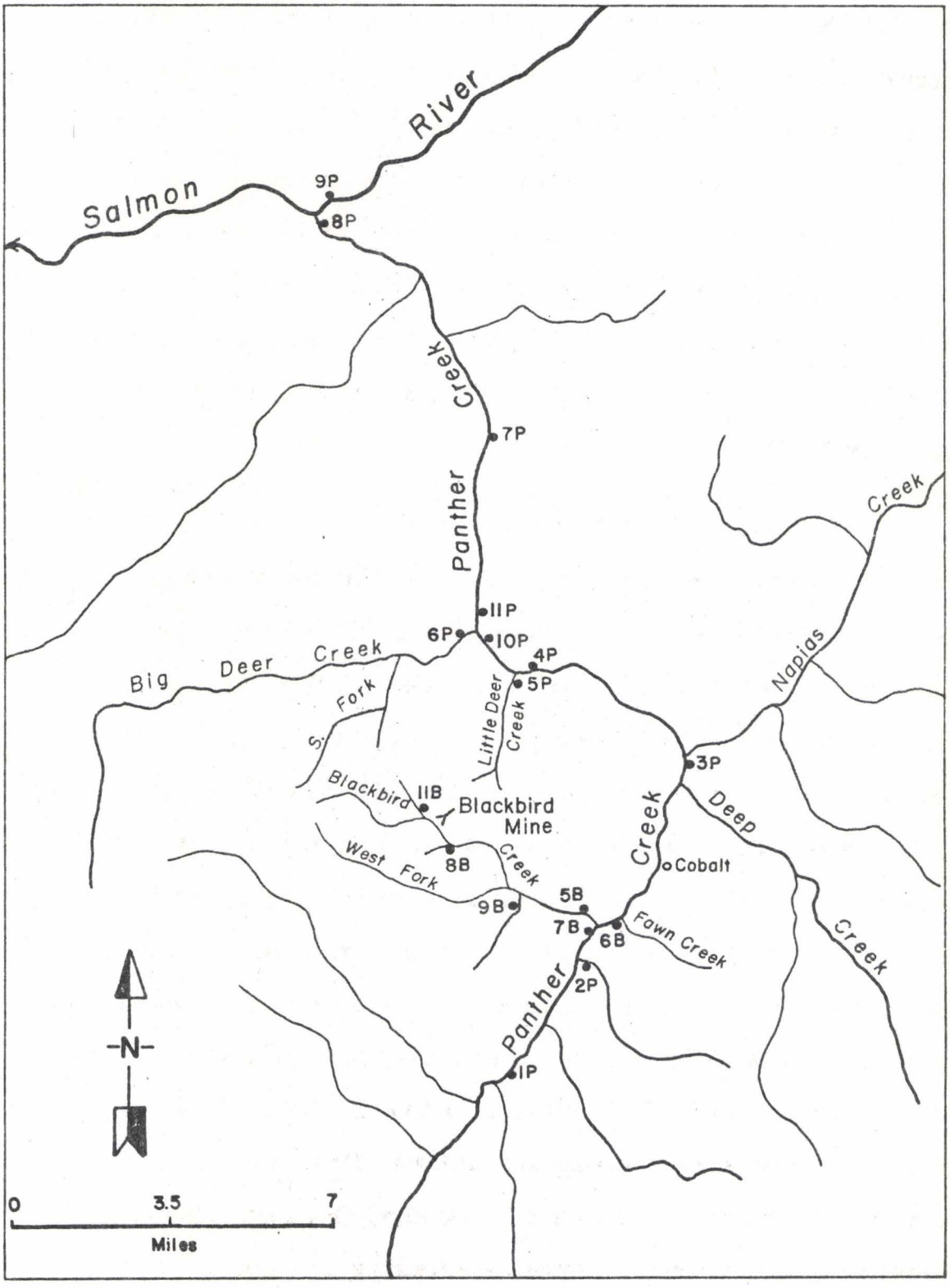


Figure II-1. Location of sampling stations established by Platts, 1967.

analysis was done by the Idaho Health Department (now the Idaho Department of Health and Welfare). Samples were also analyzed by the Pacific Northwest Water Laboratory, Federal Water Pollution Control Administration, Department of the Interior (Platts, 1967). Metal ion concentrations were determined using an atomic absorption spectrophotometer. Water samples were collected in standard plastic containers which had been pre-rinsed with distilled water. The containers were rinsed with the water to be collected and the sample was then collected and saved. Samples were acidified with 1 ml of either HCl or HNO_3. Results of analysis of the samples are presented in Appendices I-1 through I-4.

1969 Data Collection

The Idaho Mining Company began a data collection program with acquisition of the mining property. Water samples were collected approximately five days per week from February 24 through October 3, 1969. More than 700 water samples were analyzed by Idaho Mining personnel for pH, cobalt, copper, and iron during this period (McAuliffe, 1975, written communication). Seven sample stations were established in the data collection network. The stations correspond to stations 7, 9, 10A, 15, 20, 22, and 23 of the University of Idaho data collection network. The locations of these stations are shown on Figures II-2, II-3, and II-4. Metal concentrations were determined using a Perkin-Elmer 303 Atomic Absorption Spectrophotometer, pH values were determined with an Ion Research Model 610 digital IONANALYZER. These instruments are located in Cobalt and are owned by the Idaho Mining Company. Discharge data were collected at all seven sample stations. However, information concerning methods and procedures of discharge measurement are not available. Metal ion concentrations and discharge data are presented in Appendix II-1.

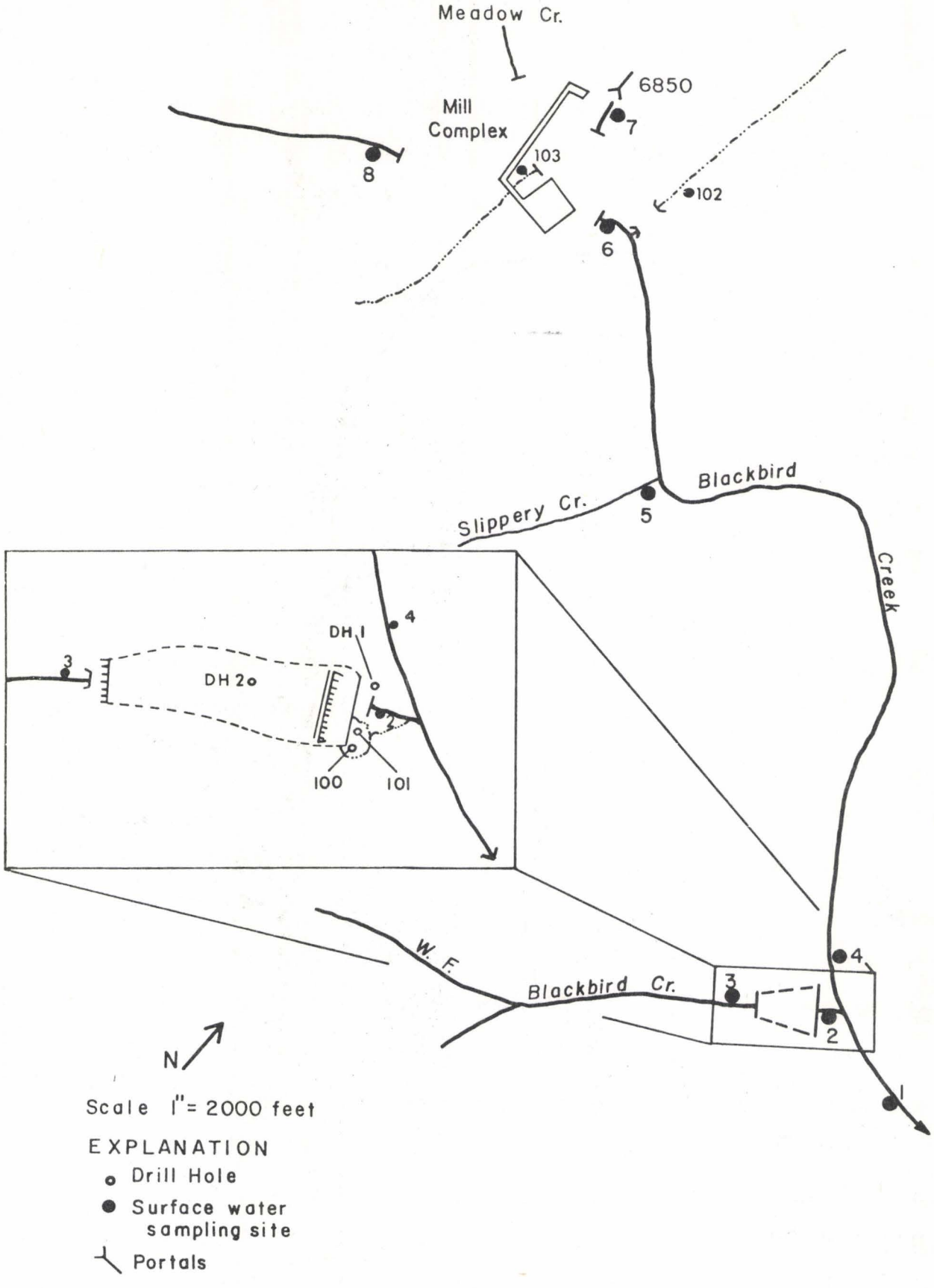


Figure II-2. Location of University of Idaho sampling stations on Blackbird Creek.

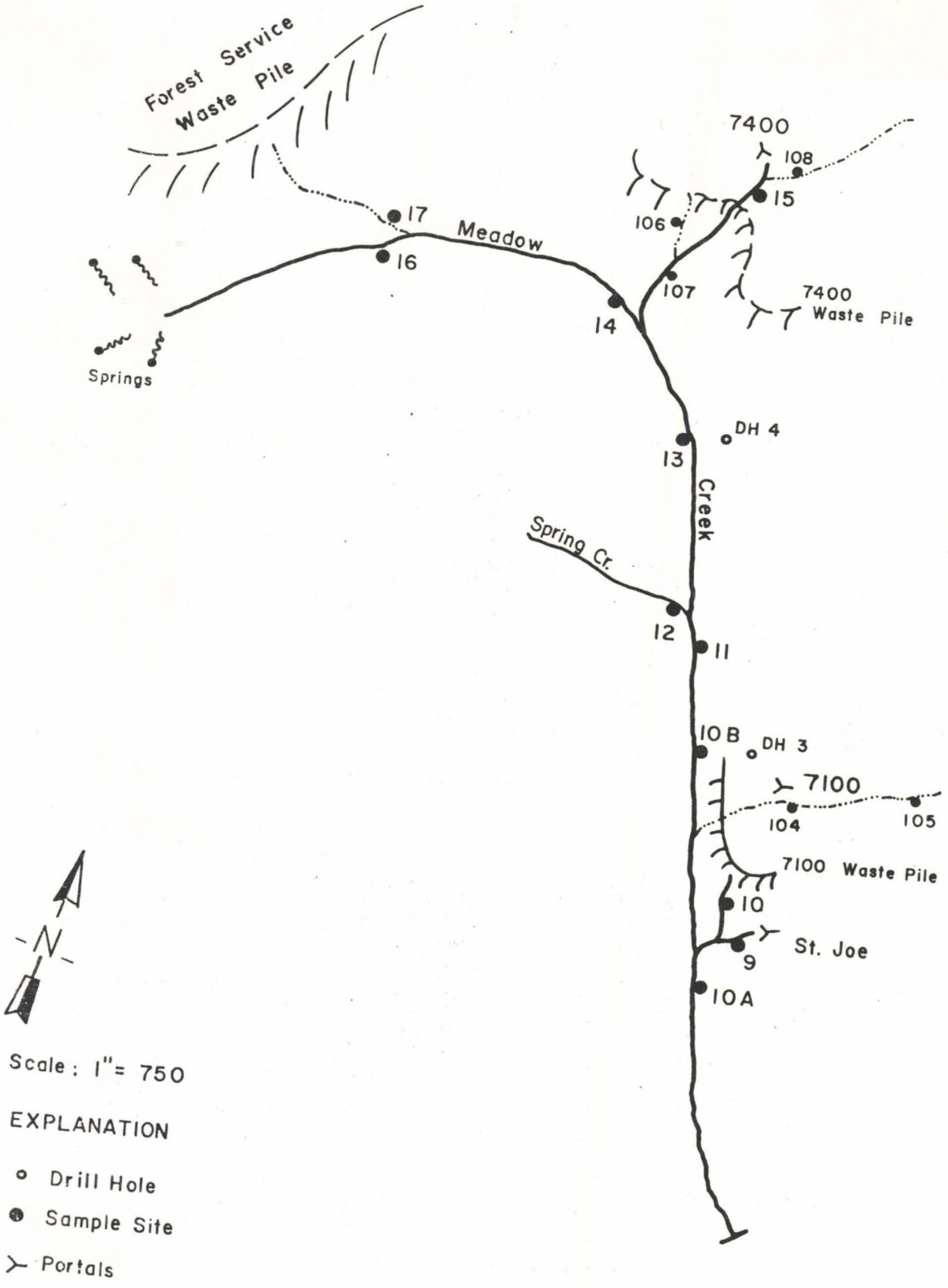


Figure II-3. Location of University of Idaho sampling stations on Meadow Creek.

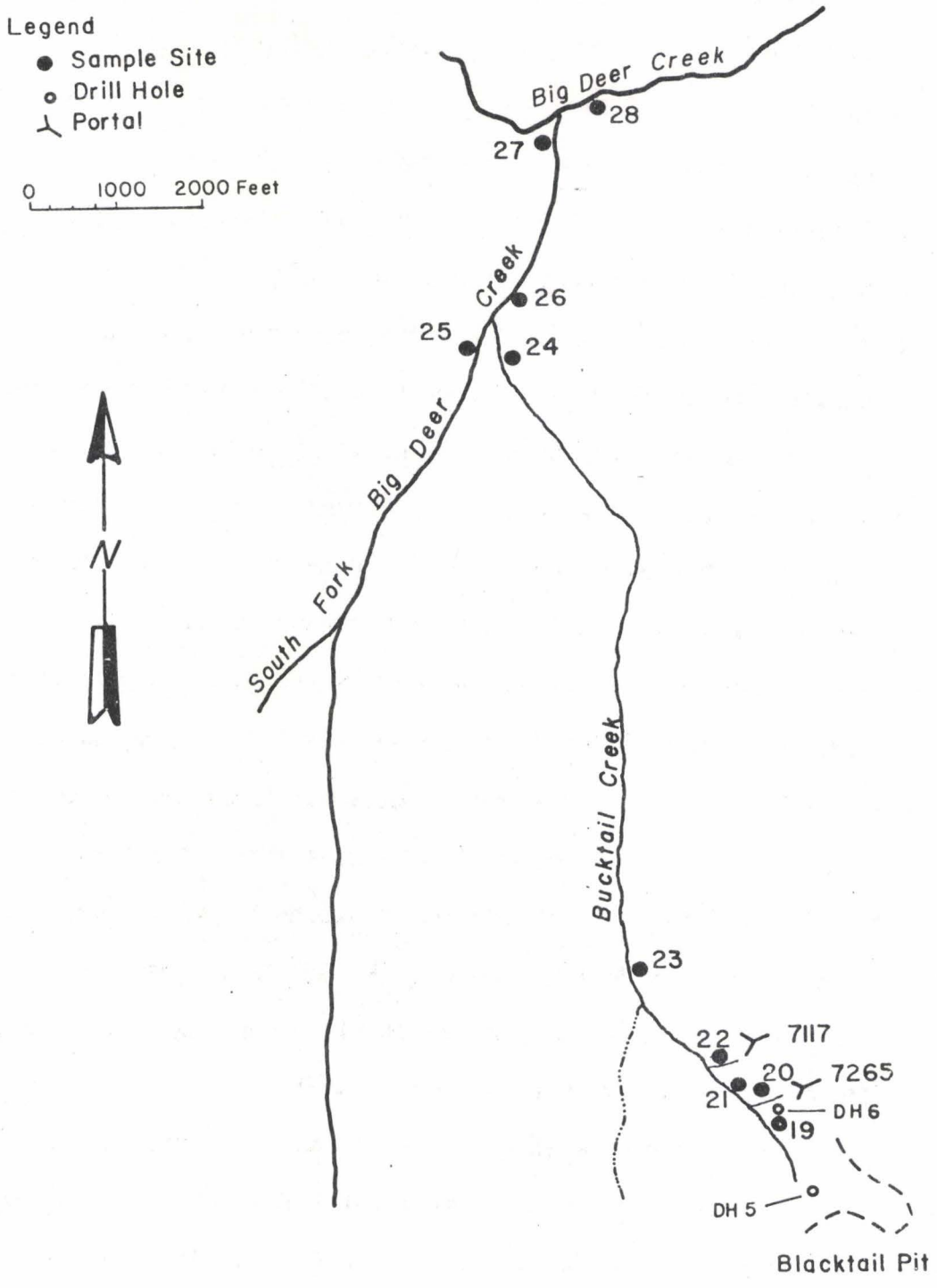


Figure II-4. Location of University of Idaho sampling stations on Bucktail Creek.

1971 Data Collection

Sampling was not conducted during 1970, but beginning in 1971, sampling was conducted by the Idaho Mining Company, USDA-Forest Service and the Idaho Department of Health. The bulk of the sampling was done by the Idaho Mining Company. A total of 366 water samples were collected intermittently during the period February 25 through December 2, 1971. Sampling frequency was increased during the spring runoff. Samples collected by Idaho Mining Company personnel were analyzed for cobalt, copper, and iron concentrations. However, no pH values were recorded for the samples. Samples collected by mining company personnel were analyzed using the atomic absorption unit located at Cobalt. Forest Service and Idaho Department of Health personnel collected samples on an intermittent basis. Metal ion concentrations were reported for cobalt, copper and iron. It is not known where these agencies preformed analysis of the samples, nor what methods were used in sample collection. No pH values are available for the samples. Thirteen sample stations were established in this data collection program. Six of the stations correspond to sample stations 2, 3, 6, 7, 8 and 10A of the University of Idaho data collection network. These stations are shown on Figures II-2 and II-3. The remaining sample stations were stations 5B, 6B, 7B, 6P, 10P, and 11P, established by Platts in 1967. The location of these stations is shown on Figure II-1.

Discharge measurements were also taken intermittently throughout the year at 10 of 13 sample stations. No information is available regarding stream gaging procedures used in this data collection program. Metal ion concentrations and discharge data are presented in Appendix II-2.

University of Idaho Data Collection Program

During the 1974, 1975, and 1976 field seasons, University of Idaho personnel collected water quality and water quantity data in the Blackbird Mining area. The objective of this data collection program was to gather field information: (1) which could be used to define areas and mechanisms of acid mine drainage production, and (2) which could be used to define relative contributions from the various sources of acid mine drainage production.

Water Quality

The method of collection and treatment of water samples from an acid drainage situation can have a major impact on results of the analysis. Samples which contain large amounts of suspended material with sizes in the colloidal range may indicate higher metal ion concentrations from atomic absorption analysis than actually exist in the dissolved state. Dissolved ions contained in acid mine water samples are often unstable. When oxygen deficient mine water comes into contact with atmospheric conditions, ions in the lower valance states can be oxidized to higher valance states and metal in solution are precipitated out of solution.

Filtration, acidification, and freezing are three methods of treatment which can be applied to acid mine water samples. Opinions differ as to the effectiveness of filtration and acidification. Williams and Mink (1975, p. 9) elected to analyze unacidified water samples because increased lead and zinc concentrations were noted in acidified samples. However, Brown and others (1970, p. 6) noted that acidification reduces oxidation and precipitation effects and minimizes adsorption to container surfaces.

Kennedy and others (1974, p. 785) reported that Fe and Al concentrations varied by as much as a factor of ten after filtration through a 0.45 mm (millimeter) membrane filter. This variance was attributed to passage of fine grained material through the filter. Filtration does not give precise separation of suspended and dissolved constituents but is the best method available (Hem, 1970, p. 88). Filtration is still accepted as the best method for the separation of suspended and dissolved constituents.

Sample Collection and Treatment

All water samples were collected as grab samples in polyethylene bottles which had been washed, rinsed in a 50 percent solution of nitric acid, and rinsed in distilled water. Bottles were rinsed with the water being sampled at the time of collection. Electricial conductivity and pH values were determined immediately after collection. Dissolved metals were determined using the atomic absorption unit located at Cobalt or a similar unit located in the Idaho Bureau of Mines and Geology laboratory, Moscow, Idaho. The analyses were performed using methods outlined in "Standard Methods for Examination of Water and Waste-water" (1975).

During the 1974 and 1975 field seasons, water samples collected were neither filtered nor acidified. All samples were analyzed shortly after collection. Following a review of the literature, the decision was made to filter and acidify samples for the 1976 field season. Consequently all samples collected during the 1976 field season were first filtered through Whatman #42 filter paper and then acidified to a pH of 3.0 or less. Metal ion concentrations in water samples prepared in this manner are defined as dissolved metal ions for the purpose of this report. Dissolved material is commonly defined as that material which goes through 0.45 mm membrane filter.

Duplicate samples were collected from five locations on the 6850 level during the 1975 field season to determine the effects of filtration on metal ion concentrations. One of the duplicates was filtered through Whatman #42 filter paper following collection while the other was analyzed as collected. The samples were not acidified. Analysis of the samples was performed using the atomic absorption unit located at the IBMG office in Moscow. The results of the anlaysis of these samples are presented in Table II-2. Iron, magnesium and manganese concentrations were lower for filtered than unfiltered samples at the .05 level of significance. This suggests that filtration removed suspended materials carrying iron, magnesium, and manganese ions from the sample. Concentrations of calcium and sodium were significantly higher for the filtered samples than the unfiltered samples at the .05 level of significance. Four 500 milliliter (ml) distilled water samples were analyzed for Na and Ca to determine if these ions were assoicated with filtration. One half of each 500 ml sample of distilled water was filtered through a 6-inch Whatman #42 filter paper while the other was not. Analysis of the samples was done using the IBMG atomic absorption unit. None of the samples were acidified. Results of the analysis of the four samples, presented in Table II-3, clearly shows that the filter paper is a source of Na and Ca ions. This accounts for the increased Na and Ca concentrations noted in Table II-2. Copper, cobalt, and potassium concentrations showed no significant change between unfiltered and filtered samples.

Analytical results for filtered and unfiltered samples which had not been acidified would be markedly different from filtered and unfiltered samples which had been acidified. Acidification would strip metal ions from suspended

Table II-2. Results of analysis of unfiltered anf filtered water samples - 6850 level, Blackbird Mine. (All results are in parts per million.)

Date	Sample Number	Location	Ca	Mg	Na	K	Fe	Cu	Mn	Co	pH
4/16/75	90U	Calera Winze on 6850	4.7	13.8	5.4	10.3	30.5	0.1	3.9	1.7	4.2
	90F	level at 20 feet depth	5.6	13.7	7.7	10.2	27.5	0.1	3.7	1.7	
4/16/75	91U	Calera Winze on 6850	4.6	13.9	5.8	10.2	22.6	0.2	3.8	1.7	4.2
	91F	level at 150 feet depth	6.0	13.6	8.2	9.6	17.8	0.2	3.6	1.7	
4/16/75	92U	Pierce Winze on 6850	8.5	16.4	6.2	11.6	64.4	0.0	4.0	2.3	4.6
	92F	level at 0 feet depth	9.7	15.9	8.6	11.6	61.0	0.0	3.8	2.3	
4/18/75	93U	Pierce Winze on 6850	8.7	16.4	6.1	11.1	38.0	0.8	4.0	2.3	5.1
	93F	level at 9 feet depth	10.1	16.2	9.6	11.3	33.8	0.8	3.8	2.2	
4/18/75	94U	Pierce Winze on 6850	9.0	16.5	6.1	11.9	38.3	0.1	4.0	2.4	5.6
	94F	level at 20 feet depth	9.8	16.4	8.6	11.6	32.9	0.1	4.0	2.3	

U - Sample not filtered
F - Sample filtered through Whatman #42 filter paper

materials, and place the ions in solution. The metal ions could then pass through the filter paper and metal ion concentrations of filtered and unfiltered samples should be approximately the same.

Table II-3. Results of analysis of filterd and unfiltered samples of distilled water. (All results are in parts per million).

Sample Number	Metal Ion	
	Cu	Na
1U	0.0	0.0
1F	0.5	2.7
2U	0.0	0.0
2F	0.45	2.5
3U	0.0	0.0
3F	0.7	2.1
4U	0.0	0.0
4F	0.5	1.6

U - Sample not filtered
F - Sample filtered through Whatman #42 filter paper

Criteria for Contamination

To determine the full extent of the effect of effluent from mining features in the Blackbird Mining District, it was necessary to determine the nature of the geochemical background in unaffected areas. Samples were taken from Panther Creek above Blackbird Creek, Deep Creek, Napias Creek, Big Jureano Creek, Little Deer Creek, and two creeks of no name to provide background levels for the area (Figure II-1). Average background values for these streams in non-mined areas were:

pH	6.4
copper	trace
cobalt	0.1 ppm
iron	0.1 ppm
manganese	trace

Surface Water Sampling Locations

A data collection network of 28 stations was established for sampling of discharge from waste features, mine portals and streams during the 1974 field season. Water samples were collected weekly during the summer months and monthly during the autumn months until freezing conditions prevented further sampling. The location of sample stations established during the 1974 field season is shown on Figures II-2, II-3, and II-4. Ten sampling stations were located on Blackbird Creek (Figure II-2). Analysis of samples collected from four of the stations indicated good quality water: the West Fork of Blackbird Creek, Slippery Gulch and the reaches of Blackbird Creek above the confluence with Meadow Creek. Poor quality water enters Blackbird Creek from Meadow Creek and the 6850' portal.

Eleven sample stations were located to monitor the quality of water in Meadow Creek (Figure II-3). The water quality in the upper reaches of Meadow Creek is good. Poor quality water seeps from a large waste pile (Forest Service Re-Vegetation Research Area). Additional poor quality water discharges to Meadow Creek from the 7400' portal, seeps from the 7100' waste pile and flow from the St. Joe portal. Meadow Creek discharges into Blackbird Creek at the mine office and mill complex.

Ten sampling stations were located along Bucktail Creek and the South Fork of Big Deer Creek (Figure II-4). Poor quality water exists along the entire length of Bucktail Creek and throughout the lower reaches of the South Fork of Big Deer Creek. Water of poor quality is found at the source of Bucktail Creek near the base of the Blacktail Pit waste pile. Additional poor quality water enters the creek by portal drainage from the 7265' and 7117' levels. Adverse effects of this poor quality water is not reduced until mixing with Big Deer Creek occurs.

Eighteen additional surface sampling stations were added to the network in the spring of 1975 (Figures II-2, II-3, and II-4). These stations were located in areas which would allow sampling of spring runoff from areas which are dry during the summer months and to determine quality characteristics during spring runoff. Samples of runoff from areas such as gullies, roads, waste pile runoff and tailings pile seeps were collected at eleven of the sample stations. Poor quality water was noted issuing from the base of the tailings pile located on the West Fork of Blackbird Creek (stations 100 and 101). Stations 102, 103, 105, 106, 107, and 108 were located at gullies discharging spring runoff water. In general, the quality of water issuing from these small drainages was good. Stations 106 and 107 were located at the botton of 7400' waste pile. The quality of this water was similar to that of the 7400' portal. Sample stations 109 and 110 were located near the mouth of the Blacktail Pit and represented overland runoff on waste material. Station 109 was taken at an approximate elevation of 7525 feet and sample 110 was taken approximately 100 feet downhill from sample 109. Water quality decreased with downhill position for the two samples. During the summer months of 1975, an additional series of eight sample stations was located on Bucktail Creek between stations 22 and 23 to identify the source of increased flow and metals noted in this section of the creek. These stations were numbered B1, B1A, B2, B3, B4, B5, B6 and B7. The location of these stations is shown on Figure II-5.

Sampling Locations in Mine Workings

A data collection network was established in the underground workings early in 1975 (see Plate I for location of sample sites). A total of 50 sample stations were located on the 6850' level. Samples were analyzed for the same metals as the surface stations. The sample stations included

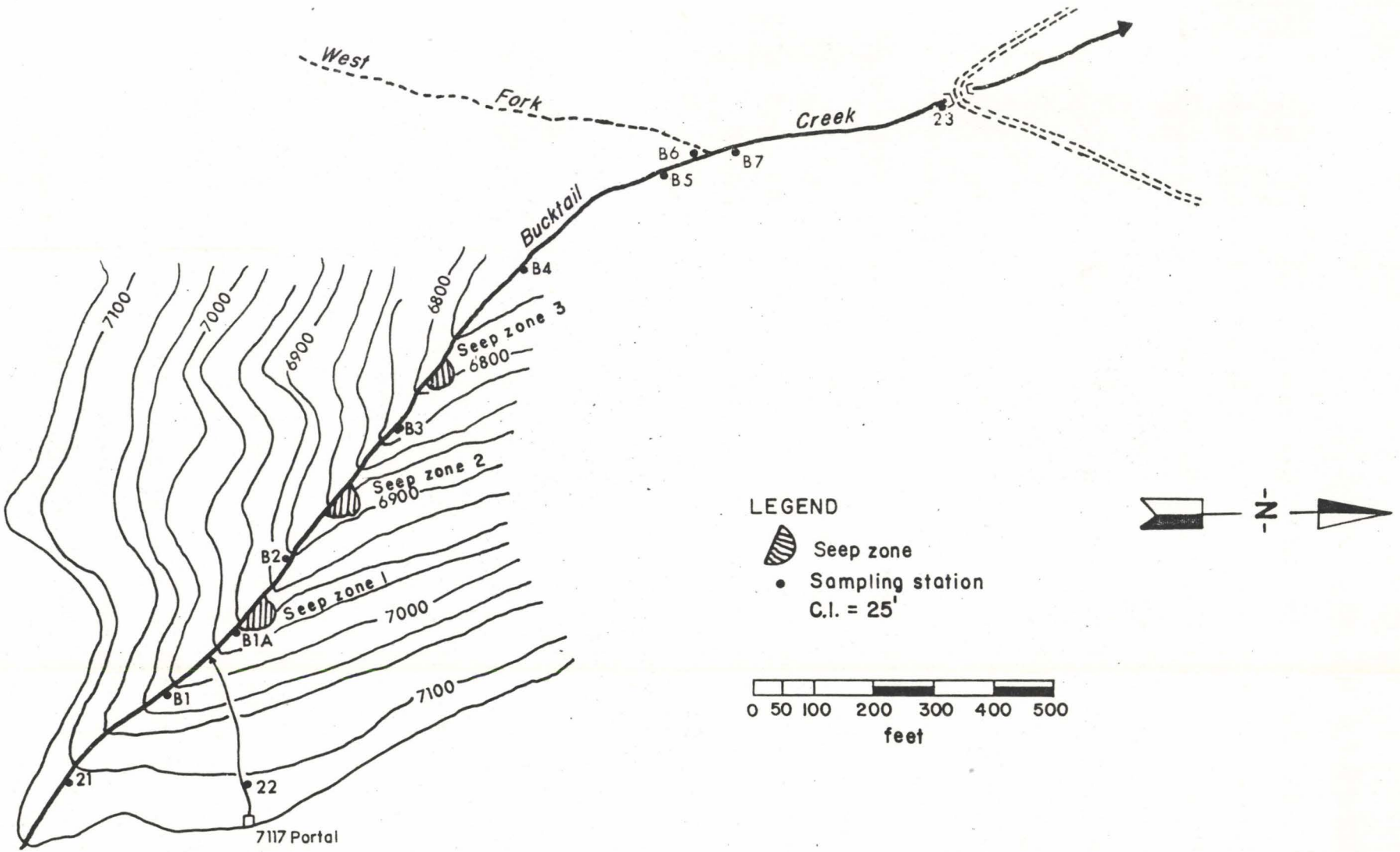


Figure II-5. Location of sampling stations B1 through B7, Bucktail creek.

diamond drill holes, raises, ore passes, and two winzes (inclined shafts connecting two levels). All levels below the 6850' are flooded. Thirteen and fourteen sample stations were located on the 7000' and 7100' levels respectively during the same period. Sampling of these stations was not as frequent as on the 6850' level. Only limited sampling of the 7200' and 7300' levels was done due to deteriorating physical conditions on these levels. A total of seven stations were located on these two levels. Fifteen sample stations were located on the 7400' level; discharge at these sites was sampled during the 1975 and 1976 field seasons. An intensive sample collection period was carried out during the high runoff peroid of 1976 on the 6850' level. This collection program was designed to better define recharge relationships occurring during the high runoff period.

Ground-Water Sampling Locations

Ground-water conditions in the study area were investigated in a drilling program conducted during May and June of 1976. A total of seven piezometers were installed in six drill holes located in the study area. The drill holes were completed with an Acker trailer-mounted drill furnished by Boise State University. Approximately 270 feet of drilling was completed and three-quarter-inch PVC pipe was placed in the holes to serve as a casing. All of the holes were completed in mine waste material and all encountered poor quality water. Locations of the piezometers are shown on Figures II-2, II-3, and II-4. Drill holes 1 and 2 were located on and downstream of the West Fork tailings pile to monitor ground-water conditions in this area. Drill holes 3 and 4 were located in the Meadow Creek drainage. Two piezometers were installed in drill hole 3 to monitor ground-water quality at different depths. Drill

hole 5 was located on the Blacktail pit waste pile and penetrated the entire depth of the waste pile. Drill hole 6 was located in the 7265 waste pile and also penetrated the total depth of the waste pile.

Water Quantity

Streamflow Measurement Sites

Stream discharge was measured at weirs and flumes installed on Blackbird, Meadow, and Bucktail Creeks, the three major streams in the study area. Stage was recorded daily or continuously at the weirs and flumes and discharge was inferred from a stage-discharge graph. Flow on Blackbird Creek was monitored at station 4 using a rectangular weir with a crest length of 5.75 feet and a Stevens Type F continuous water level recorder. Rectangular weirs are normally constructed so that the velocity of approach to the weir is as small as practical (U. S. Bureau of Reclamation, 1975, p. 25). Weir pools should be maintained behind the weir to achieve low approach velocities. During the 1974 and 1975 field seasons, it was not possible to maintain a weir pool at station 4 and no lateral contraction took place as Blackbird Creek flowed through the weir. The weir met the requirements of a standard suppressed rectangular weir in this configuration (U. S. Bureau of Reclamation, 1975, p. 13). A velocity correction factor was added to discharge computations at the weir during 1974 and 1975.

The approximate discharge at the weir was first determined and the velocity of approach was then calculated from the equation (U. S. Bureau of Reclamation, 1975, p. 25):

$$V = \frac{Q}{A} \qquad (7)$$

where:

V = velocity of approach in feet per second
Q = discharge in cubic feet per second, and
A = cross-sectional area of the approach channel in square feet

The cross-sectional area at the weir crest was used in place of the cross-sectional area of the approach channel for the purposes of these calculations. Knowing the value of V the velocity of approach head was computed from the equation:

$$h = \frac{V^2}{2g} = 0.0156\ V^2 \qquad (8)$$

where:

h = head in feet due to the velocity of approach, and
g = gravitational constant.

The discharge was then computed by

$$Q' = 3.33\ L\ [(H + h)^{3/2} - h^{3/2}] \qquad (9)$$

where:

Q' = discharge in cubic feet per second, considering velocity of approach
L = length of the weir in feet, and
H = head on the weir in feet.

The discharge data obtained by the use of this method are given in Appendix III-2.

During the 1976 field season, a weir pool was maintained at station 4 and approach velocities were within acceptable limits. The weir was treated as a standard contracted rectangular weir and the equation

$$Q = 3.33\ LH^{3/2} \qquad (10)$$

was used to compute discharge (U. S. Bureau of Reclamation, 1975, p. 25). Letters in this equation are defined previously. Accuracy of the weir was checked by comparing discharge values computed from the above formula against

22 discharge measurements made by Forest Service personnel using a Pygmy current meter. Comparison of the data show that the weir discharge values are within 5 percent of the current meter discharge values. This difference is within measurement error. Discharge data for 1976 obtained by the use of equation (10) are given in Appendix III-2.

Discharge measurements on Meadow Creek were made at station 10A during the 1974 and 1975 field seasons with a Parshall flume with a one-foot throat width. The head on the flume was converted to discharge by the use of standard weir tables. The acidic mine water had destroyed this flume by the end of the 1975 field season and discharge measurements during 1976 were made using a 55 gallon barrel and a stop watch. A Parshall flume with a 6-inch throat width was used to measure stage on Bucktail Creek during 1974 and 1975 at station 23. A 90-degree V-notch weir was installed to replace this flume for the 1976 field season. Discharge data for stations 10A and 23 are given in Appendix III-2.

Discharge from Mine and Surface Waste Features

Discharge from mine and surface waste features included flow from waste piles, mine portals and two stations within the mine workings. These discharge points were identified as sources of poor quality water and discharge measurements were necessary to compute volumes of poor-quality water produced and metal loads contained in this discharge. These discharge points were measured at culverts using a bucket and stop watch, with 90-degree V-notch weirs, and with a rectangular weir and continuous recorder. Table II-4 lists the various stations and measurement methods used. Stations 7, 6827, and 68616 were located in mine workings and were accessible throughout the year. Discharge at station 7 was monitored during the late summer of 1974 and from early spring

Table II-4. Measurement methods for mine and surface waste discharge points, Blackbird Mine.

Station	Measurement Method
7	Rectangular weir and Stephens Type F continuous recorder
9	90-degree V-notch weir
10	Culvert with bucket and stop watch
15	90-degree V-notch weir
17	90-degree V-notch weir
20	Culvert with bucket and stop watch
22	Culvert with bucket and stop watch
B1	Culvert with bucket and stop watch
B1A	Culvert with bucket and stop watch
B2	Culvert with bucket and stop watch
B3	Culvert with bucket and stop watch
B4	Culvert with bucket and stop watch
B5	Culvert with bucket and stop watch
B6	Culvert with bucket and stop watch
B7	Culvert with bucket and stop watch
6827	90-degree V-notch weir
6816	90-degree V-notch weir

through late fall of 1975 and 1976. Discharge measurements were made on an irregular basis at stations 6827 and 68616 during the 1976 field season only. The remainder of the discharge stations listed on Table II-4 were inaccessible during the spring months due to heavy snow accumulations and discharge measurements were limited to the summer months. During these summer months, discharge was recorded approximately once a week per station.

Recharge Conditions

Surface Mapping

Areas of potential surface recharge to the mining features were investigated in the summer of 1974. Exploration trenches, pits, collapse features, and geologic structures were mapped.

Drill Hole Dye Injections

The total footage of drill holes in the mining area probably exceeds 100,000 feet. Most of the drill holes penetrate faults and permeable ore zones, and many terminate near existing underground workings. A dye-water solution was injected in selected drill holes during the 1975 and 1976 field seasons to determine if recharge to these holes would discharge in parts of the underground workings. Samples were obtained at selected sites under-ground for visual observation and fluorometric analysis.

CHAPTER III

ANALYSIS OF DATA - BLACKBIRD CREEK DRAINAGE

Blackbird Creek Drainage Area

The Blackbird Creek drainage includes an area of about 14,700 acres (23 mi^2). No permanent stream gaging stations are maintained in this drainage but the discharge at numerous points has been monitored since investigations began in the area in 1969. Station 5B was located at the mouth of Blackbird Creek and measured discharge from the entire Blackbird Creek drainage. This situation was monitored by the U.S. Geological Survey for 1971 only (Figure III-1). For the 1974, 1975, and 1976 field seasons, Blackbird Creek discharge was monitored at station 4. At this point, Blackbird Creek drains an area of about 5,500 acres (8.6 mi^2), roughly one third of the total drainage basin. Table III-1 lists points for which discharge data are available and length of record for these stations.

Water quality at station 4 reflects input from point sources of acid discharge such as station 7 (6850 portal) and station 10A (Meadow Creek). Water quality at station 7 reflects input from points sources of acid discharge in the underground workings. Likewise, water quality at station 10A reflects input from point sources of acid discharge such as station 9 (St. Joe portal), station 10 (7100 waste pile), station 15 (7400 portal), and station 17 (F. S. waste pile). The Meadow Creek drainage includes an area of about 500 acres within the Blackbird Creek drainage.

Point Sources of Acid Contribution in the Blackbird Creek Drainage

Point sources contribute varying volumes and concentrations of acid

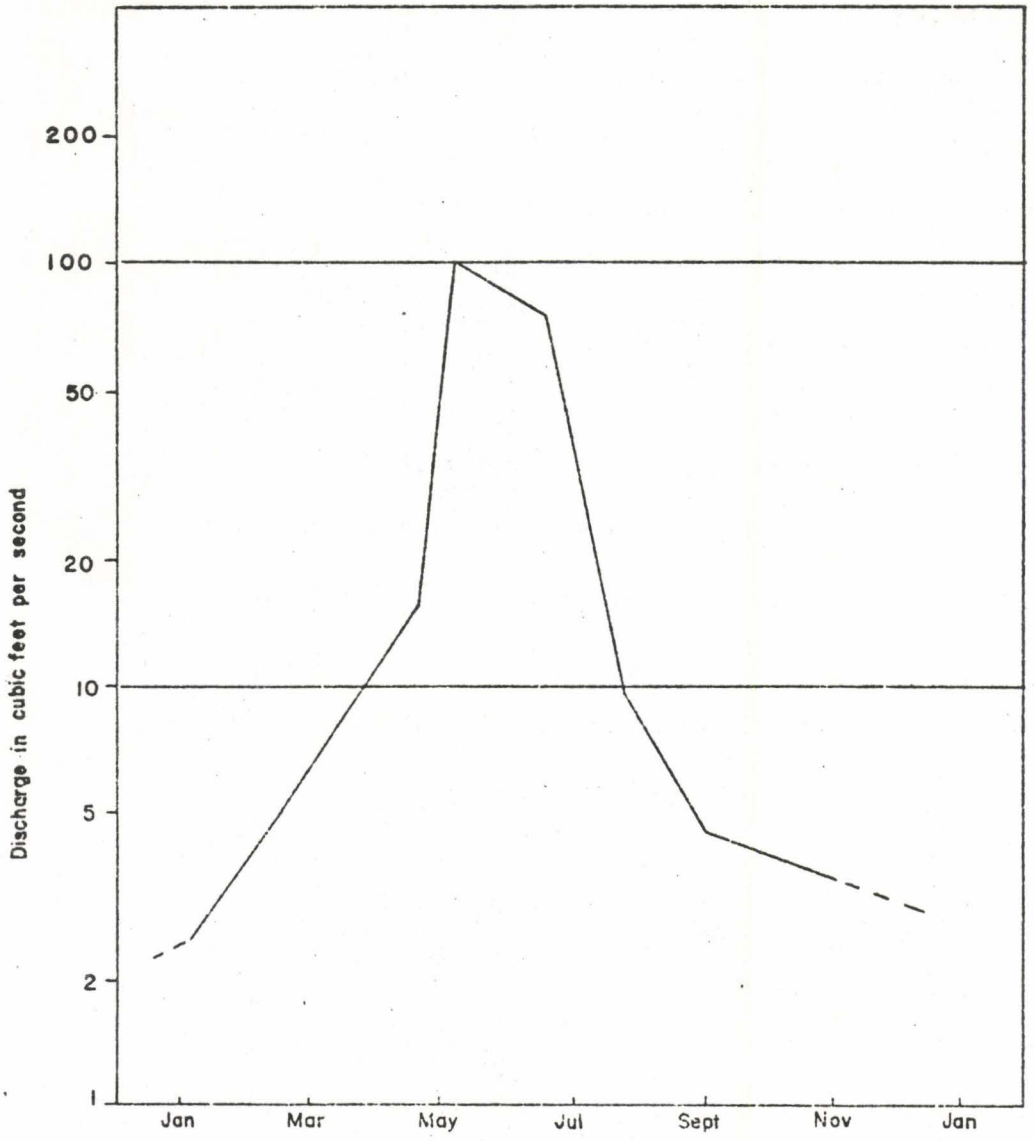


Figure III-1. Streamflow hydrograph of Blackbird Creek at mouth for 1971 (US Geol. Survey data).

Table III-1. Discharge stations in Blackbird Creek drainage with periods for which data are available.

Station	Period of Record				
	1969	1971	1974	1975	1976
5B (Blackbird Creek)	----	2-18 to 11-09	----	----	----
4 (Blackbird Creek)	----	----	7-21 to 8-25	4-01 to 9-30	3-18 to 9-09
6 (Upper Blackbird Creek)	----	4-14 to 11-09	----	----	5-20 to 7-12
7 (6850' portal)	2-25 to 10-03	6-21 to 11-01	8-04 to 12-31	4-19 to 9-14	3-18 to 9-09
9 (St. Joe Shaft)	7-16 to 9-10	----	8-11 to 11-02	6-03 to 8-01	5-05 to 8-03
10 (7100' waste pile)	----	----	7-12 to 11-02	6-03 to 8-01	4-29 to 8-03
10A (Meadow Creek)	2-26 to 9-30	3-31 to 11-09	7-21 to 11-02	6-03 to 10-04	5-18 to 8-03
13 (Upper Meadow Creek)	----	----	----	----	5-20 to 6-24
15 (7400' portal)	2-24 to 10-01	----	7-21 to 11-02	6-20 to 8-01	4-13 to 8-03
17 (F. S. waste pile)	----	----	----	----	5-19 to 6-29

water and heavy metals to Meadow Creek and Blackbird Creek. Point source discharges can be divided into discharge from surface waste features (Forest Service Revegetation Research Waste Pile, 7400 waste pile, and 7100 waste pile), and discharge from mine workings (7400 portal, 7200 portal, St. Joe portal, and 6850 portal).

Surface Waste Features

Ground-water flow systems which give rise to point discharge sources in the various surface waste piles did not exist prior to the creation of the waste piles. For the purpose of the following discussions, a surface waste ground-water flow system is defined as one which has developed in a mine-related surface waste feature.

Forest Service Revegetation Research Waste Pile

The Forest Service Revegetation Research Waste Pile (F. S. Waste Pile) is located at an elevation of 7,750 feet at the headwaters of Meadow Creek (Figure II-3). About 1.1 million cubic yards of waste are included in the pile. Meadow Creek originates in a gully which borders this waste pile on the west. Springs located at the base of the waste pile contribute to flow in the upper part of Meadow Creek during spring runoff. Melting snowbanks on the flat-topped waste pile are believed to supply water for these springs. Air photos taken during the spring runoff period of 1974 show that meltwater travels only a short distance from snowbanks before infiltrating the waste pile material.

Measurements of conductivity and pH made at these springs during high runoff of 1975 show this water to be of good quality, as is water at station 16 (Appendix II-1). This indicates that the southern tip of

the waste pile is not a source of acid production. Waste rock in the area probably contains small amounts of sulfide minerals. Farmer and others (1976) note that this area supports the only vegetation to grow on the waste pile after 20 years.

Waste pile material in the area of station 17 consists of low-grade ore stockpiled there during development of the Blacktail Pit. Analysis of this material (Farmer and others, 1976, p. 6) indicates that large amounts of sulfide minerals are present. Enough moisture is present to allow oxidation of these sulfide minerals to continue throughout the year. However, enough water is available to carry away the oxidation products only during periods of high runoff. During the remainder of the year these oxidation products migrate to the surface of the waste pile and form whitish-blue accumulations of acid salts.

Large volumes of water discharging during a short period of time provide a flushing mechanism for removal of oxidation products built up during low flow periods. Figure III-2A shows metal ion concentrations at station 17 for the 1974, 1975, and 1976 field seasons. The graphs indicate that metal ion variations are not constant from year to year at station 17. Cobalt and copper concentrations dropped slightly during the 1974 low flow period. One conspicuously low copper value which occurred during October, 1974, is believed to be an analytical error. Metal ion concentrations reached a low at the end of the 1975 spring runoff period and then began to rise slightly. The discharge hydrograph for station 10A was included to show the relation between runoff and metal ion concentrations during 1975. Cobalt and copper concentrations showed a gradual increase during the 1976 sampling period.

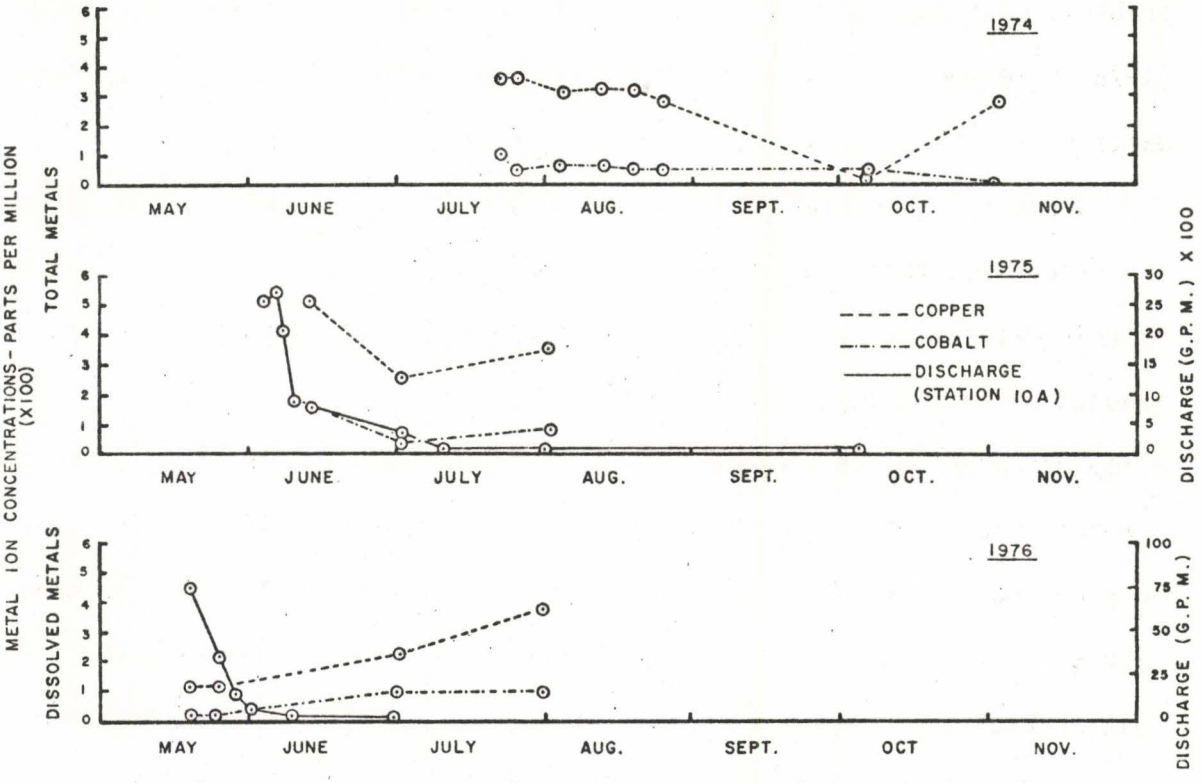


Figure III-2A. Metal ion concentrations at station 17 (Forest Service wastepile) for the 1974, 1975,and 1976 field seasons.

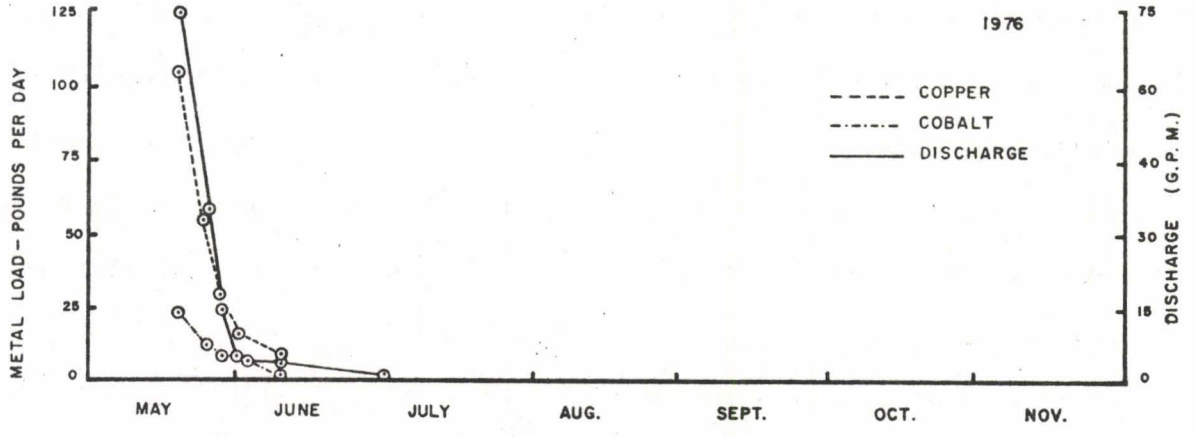


Figure III-2B. Cobalt and copper metal loads and discharge at station 17 (Forest Service waste pile) for the 1976 field season.

Revegetation work carried out on the F. S. Waste Pile during late summer, 1975, may have had an effect on water quality at station 17 for the 1976 high runoff period. About 8 inches of topsoil were spread over the waste pile, and approximately one ton of limestone per acre was applied to the topsoil and upper 6 inches of waste material. A mixture of grasses was then planted in this soil material. The effects of this revegetation program on water quality at station 17 are difficult to evaluate and may not become evident for several years, if ever.

The relation between metal ion concentrations and metal loads at station 17 is shown for 1976 data in Figures III-2A and 2B. The graphs show that while metal ion concentrations are low during periods of high runoff, the metal load is high because of the large volumes of water. Less dilution of the poor quality water occurs as runoff decreases and therefore metal ion concentrations rise during low flow periods.

Discharge at station 17 is the first point source of acid drainage to enter Meadow Creek. Flow at this station has a short duration since the surface area which is drained is only about 10 acres. Discharge dropped to less than one gallon per minute (gpm) by July 1, 1976, from an estimated peak discharge of 100 gpm during mid-May. Small seeps in the vicinity of station 17 persist into the late summer months. Dead vegetation around these seeps indicate that this was also poor quality water. These seeps are thought to represent a local ground-water flow system which drains the waste pile material in the vicinity of station 17. This would be a surface waste ground-water flow system as defined previously.

7400 Waste Pile

The 7400 waste pile consists of about 50,000 cubic yards of material. Material in this waste pile is thought to be mostly waste rock removed during development work in the underground mine workings. Acid production from this waste pile is probably limited by the low amounts of sulfide minerals present and small surface area available for recharge. Discharge from the 7400 portal flows across the surface and down the face of the waste material before entering Meadow Creek. It is felt that only a small portion of the flow from the portal recharges the waste pile as the flow channel is coated with a concrete-like layer of iron precipitate. Another possible source of recharge is spring runoff discharging onto the waste pile from a gully near the 7400 portal (station 108). Runoff from this gully is from snow melt and was estimated to have a peak discharge of one cubic foot per second (cfs) during the 1976 snow melt period. Since this runoff flows along the same channel as discharge from the 7400 portal, recharge to the waste pile is thought to be small. Water quality data for station 108 is given in Appendix III.

Only one ground-water discharge point was noted at the 7400 waste pile. Sample 106 was taken June, 1976, at a small spring discharging from the base of the waste pile (Figure II-3). The quality of this water was slightly better than discharge from the 7400 portal (Appendix III-1). Observations during the 1976 field season indicate that this spring discharge continues for a two to three week period during spring runoff. This is another surface waste ground-water flow system.

7100 Waste Pile

Waste rock and gangue material from the 7300, 7200, and 7100 levels forms the 7100 waste pile. Material in this pile is similar in volume and composition to the 7400 waste pile, but this waste pile differs from the previous two in that Meadow Creek provides a constant source of poor quality water to recharge the waste pile. This recharge appears to supply water to a spring which discharges at the base of the waste pile (station 10). The relationship of recharge to and discharge from the waste pile was documented during the summer of 1974. Rhodamine WT dye was injected in Meadow Creek above the 7100 waste pile and was detected in discharge at the base of the waste pile (station 10) after five minutes; the distance between the injection and discharge points was about 400 feet. This is another example of a surface waste ground-water flow system.

Station 10 monitored ground water discharge from the 7100 waste pile. Figure III-3 shows variations in discharge and dissolved metal ion concentrations at this station during the 1976 field season. Relative variations of metal ion concentrations are very similar to variations observed at other stations. Concentrations are high during the initial part of spring runoff, low during the latter stages of spring runoff, and increase during the summer low-flow months. Figure III-3 shows that dissolved cobalt, copper, and iron concentrations rose to the highest concentrations on April 3, 1976. Discharge data for station 10 were not available during this period, but the streamflow hydrograph for station 4 (Figure III-4) shows that a small discharge peak occurred during this same period. This initial discharge peak probably resulted from a brief warm period which

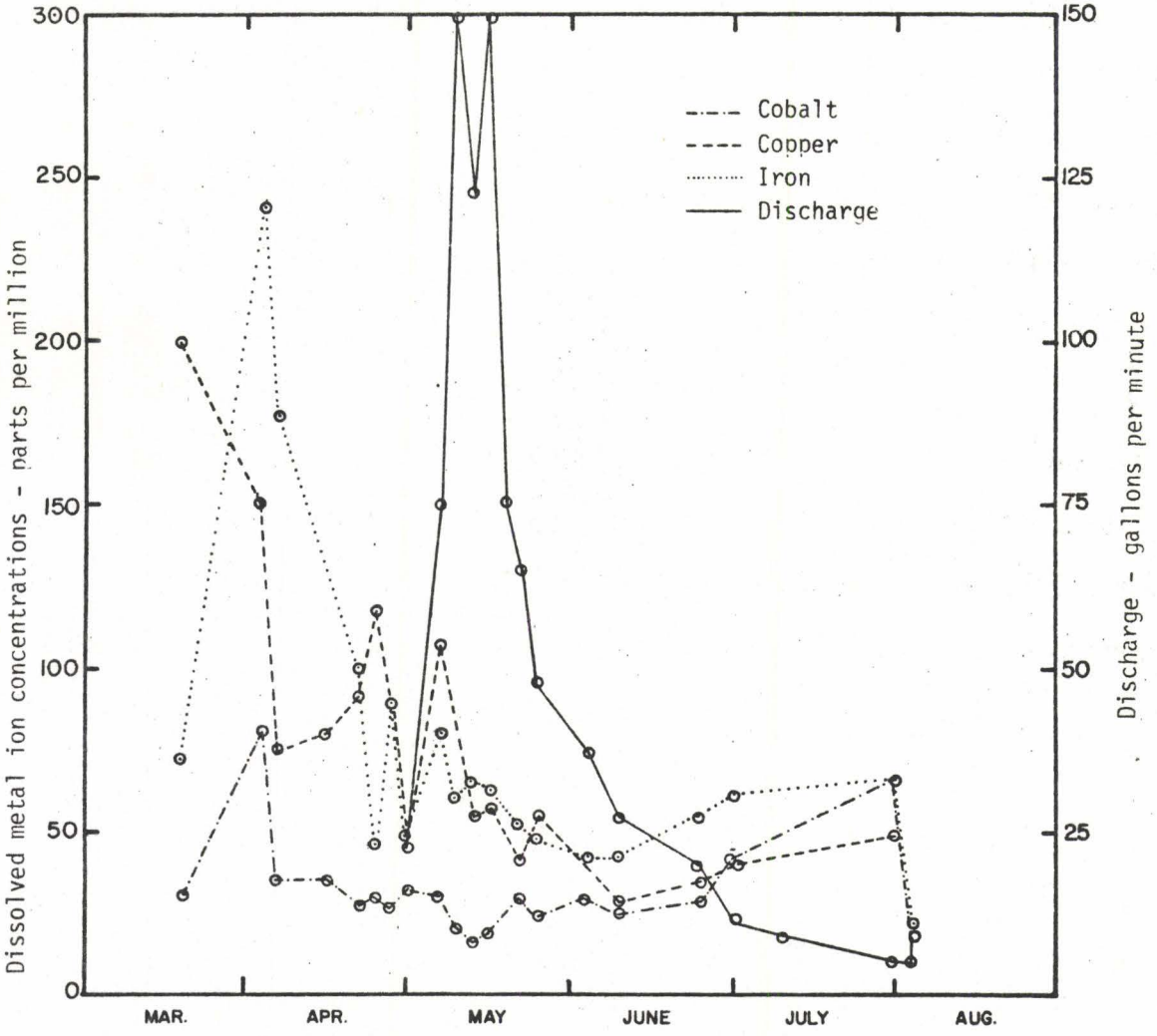


Figure III-3. Dissolved cobalt, copper, and iron concentrations at station 10 (7100 waste pile) for 1976.

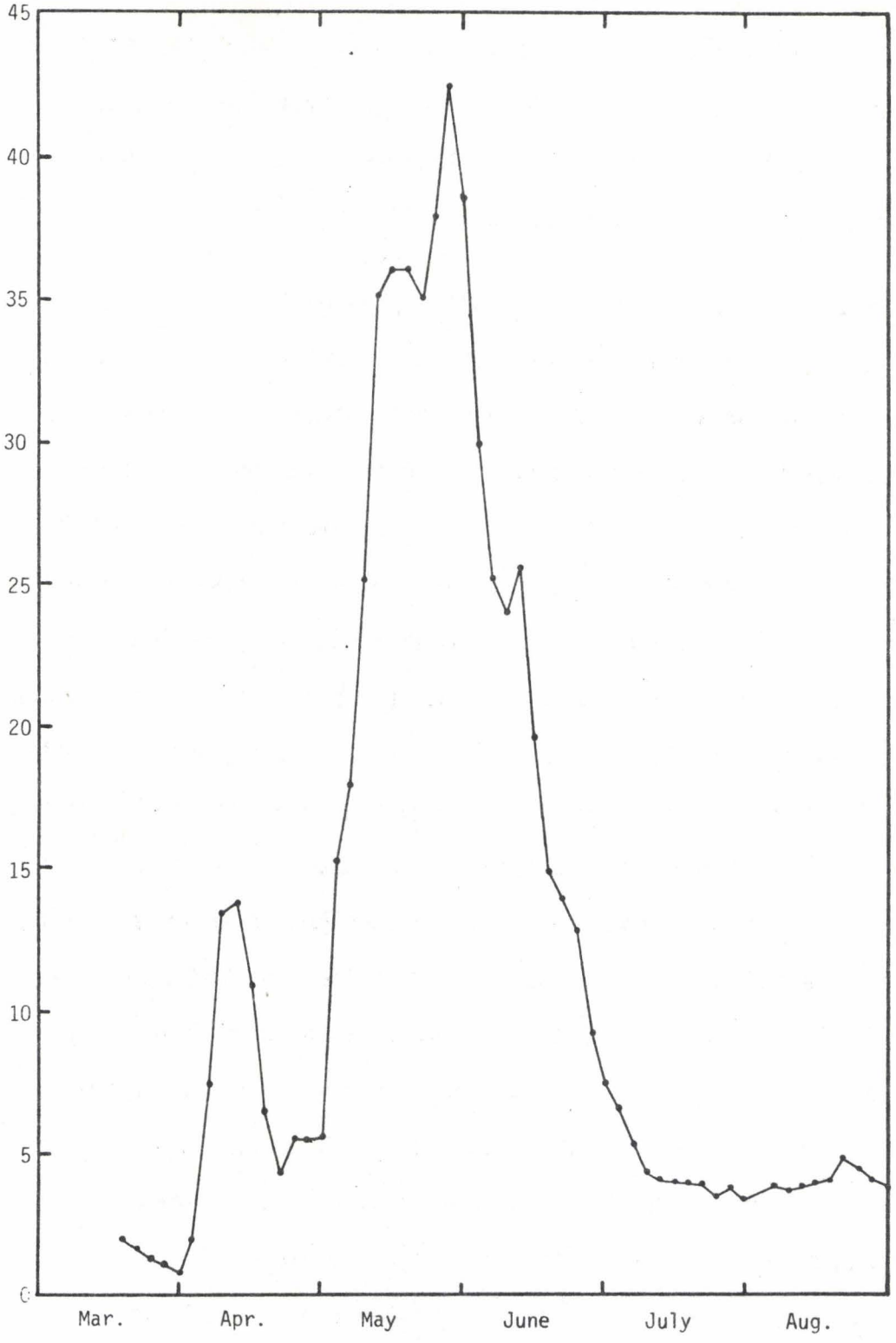


Figure III-4. Streamflow hydrograph for station 4, Balckbird Creek, for the 1976 field season.

caused some snowmelt and a rapid rise in stream discharge. This runoff was the first large volume of water in the year to flush away oxidation products formed during the preceding low flow period and consequently metal ion concentrations in this runoff were quite high.

Relative Metal Load Contributions from Surface Waste Features

An analysis of metal loads allows for an accounting of variations in discharge and metal ion concentrations. Effects of dilution can be taken into account because dilution affects concentration but not mass. Metal production from the F. S. Waste Pile (station 17) and the 7100 waste pile (station 10) was calculated for 1976. Extensive sampling of discharge from the 7400 waste pile was not done due to the short duration of flow from this source. It is felt that the amount of metal production from this source (excluding discharge from the 7400 portal) is approximately equal to metal production from the F. S. Waste Pile. In computing metal production from the 7100 waste pile, all discharge at station 10 was assumed to come from recharge from Meadow Creek. Meadow Creek above the 7100 waste pile (station 10B) carries a certain metal load and this metal load must be subtracted from the metal load at station 10 to get the actual amount of metals leached from the waste pile. Table III-2 shows both average metal load contribution in pounds per day (lb/day) and total metal contribution for the sampling period from the three waste piles. As mentioned, extensive sampling of spring discharge from the 7400 waste pile was not performed. The metal loads for this waste pile were estimated based on a discharge of 20 gpm over a three week period with cobalt, copper, and iron concentrations of 23.1, 43.0 and 0.8 ppm respectively (sample 106, Appendix III-1).

Table III-2. Average and total metal production from surface waste point discharge sources in the Meadow Creek drainage.

Station	Monitoring Period	Co		Cu		Fe	
		Average (lbs/day)	Total (lbs)	Average (lbs/day)	Total (lbs)	Average (lbs/day)	Total (lbs)
10	3/18-8/03/76	6	800	7	900	17	2300
17	5/19-6/21/76	6	200	19	600	--	----
106	Flow duration est. at 3 wks	5	100	10	200	--	----

Of the three waste piles, the 7100 (station 10) contributes the majority of both dissolved and total metal loads to the Meadow Creek drainage. Total metals were monitored during the 1974 and 1975 field seasons and dissolved metals were monitored during the 1976 field season. Measureable surface runoff from the F. S. Waste Pile probably began around May 1, 1976, but heavy snow accumulations prevented access to station 17 during the early part of the spring runoff period. However, it is felt that total cobalt and copper metal production at station 17 did not exceed 500 and 1,500 pounds respectively. Estimates of metal production from the 7400 waste pile (station 106) may be off by as much as 50 percent, but the total metal contribution would still be no greater than from the F. S. Waste Pile. Metal production from the 7100 waste pile, on the other hand, continues throughout the year and the totals given in Table III-2 represent about one third of the year. Therefore, annual metal production from the 7100 waste pile (station 10) may be as high as 2,000, 2,500, and 6,000 pounds for cobalt, copper, and iron respectively. Data for station 17 shows that average daily copper production from the F. S. Waste Pile is almost double the copper production from either the 7100 or 7400 waste piles. The high copper production reflects the fact that waste material in the vicinity

of station 17 is mostly low grade ore. This area of the F. S. Waste Pile has the potential to contribute large metal loads to Meadow Creek. All that is needed is sufficient water to transport the oxidation products.

Production of acid and heavy metals from the 7100 waste pile is greater than from the F. S. and 7400 waste piles for two reasons: (1) sufficient water is available to transport oxidation products away from the reaction site as they are formed, and (2) water recharging the waste pile material is high in dissolved iron and low-pH in nature. The role of dissolved iron in pyrite oxidation has been discussed previously where it was shown that pyrite (ferric iron) and water combine to yield acid and ferrous iron. Conditions in the 7100 waste pile should favor this reaction. Reaction 1 (p. 17) may also occur in the waste pile, with melt water or rainfall infiltration carrying reaction products from the unsaturated material to the saturated zone.

One conspicuous difference in water quality between stations 10 (7100 waste pile) and 17 (F. S. Waste Pile) is the almost complete absence of iron observed at station 17. Here, highest total iron concentrations were 2.4 parts per million (ppm) and dissolved iron was below detection limits. Total iron at station 10 was 22.7 ppm for 14 samples while dissolved iron averaged 77.4 ppm for 20 samples.

It appears that the differences in iron concentrations may be controlled in part by pH differences at the two stations. Thirty-two pH observations at station 10 averaged 2.9, while pH averaged 3.9 for 13 observations at station 17.. Hem (1970, p. 119) notes that plots of Eh-pH conditions reveal two areas where iron solubility is very low. One of these areas occur in conditions of moderate oxidation above a pH of 5, while the other occurs over

a wide pH range under strongly reducing conditions. Water recharging the waste pile should be nearly saturated with respect to oxygen and travel times through local flow systems in the waste material are not long enough to create reducing conditions. Values of pH measured at station 17 are below 5 but it is possible that pH values within the waste pile are nearer to 5, and that acidity released in the oxidation of pyrite lowers the pH of water after it leaves the reaction site. An additional source of acid entering the system would be that which is released during the formation of ferric hydroxide precipitate. For these reasons, it is believed that conditions of moderate oxidation at or near a pH of 5 exist in the F. S. Waste Pile, causing iron to precipitate in the waste material. Very little iron precipitate was observed in the drainage channel between the waste pile and station 17.

Water recharging the 7100 waste pile is low pH in nature. Nineteen observations at station 10B (Meadow Creek above the 7100 waste pile) gave an average pH of 3.5. At this pH, iron produced by the oxidation of waste pile material remains in solution and passes out of the waste pile. As noted previously, water discharging from the waste pile has an average pH of 2.9 compared with a pH of 3.5 for water entering the waste pile. The increase in H^+ concentrations is attributed to hydrogen ions released by the oxidation of pyrite and the hydrolysis of Fe^{3+}. Reactions in the 7100 waste pile might conform to the situation postulated by Wentz (1974) where the Ferrobacillus-Thiobacillus group of organisms catalyze ferrous iron oxidation and ferric iron oxidizes pyrite.

Mine Workings

Trexler (1975, p. 1) lists six variables which contribute to the production of acid water within underground mine workings. Four of these

variables (1) oxygen, (2) availablity of pyrite, (3) moisture in the mine atmosphere, and (4) availability of other heavy metals are generally not controllable in the mining process. Variables 5 and 6, availability of water to transport oxidation products, and mine characteristics, are functions of the natural hydrologic system and mining methods employed. The latter two variables are closely interrelated and may be controlled during the course of mining activities.

Natural ground-water flow systems were intercepted with the initiation of underground mining in the Blackbird area resulting in increased discharge from the flow systems. The increased discharge from the existing flow systems was compensated for by either (1) increased recharge, (2) decreased natural discharge, (3) a loss of water in storage in the system, or (4) a combination of the above processes (Theis, 1973). Three different types of flow systems are thought to contribute water to mine workings.

The first of these is defined as a discharge-modified ground-water flow system. Pre-mining ground-water flow systems have been modified by the relocation of discharge areas. Saturated fault and fracture zones intersected by mining are avenues for water movement into the mine. Raises extended near or to ground surface may encounter surface materials which become saturated during spring runoff periods. Water in this saturated material may discharge into the nearly vertical raises much as water discharges into a well. At the present time, there are about 10 miles of adits, drifts, and crosscuts in the mine and an additional 3 miles of raises, shafts, and winzes.

A second flow system is defined as a mining modified ground-water flow system. Here, the pre-mining flow system was modified by mining or exploration by changes in recharge and/or discharge areas. An example of this type of

flow system would be ground water entering surface drill holes, exploration trenches and pits, or mine related features, and discharging to mine workings.

Mining-created flow systems are defined as those where water enters directly into mine openings such as raises or open pits, flows through either sandfilled workings or open raises and drifts, and discharges from mine portals. This type of flow system may be either a ground-water or a surface-water flow system at different points in its passage through the mine workings. These three mining-influenced flow systems will be referred to in the following discussion on point source discharge from mine workings.

In the Blackbird Creek drainage, point source discharge from mine workings occurs at the 7400 portal (station 15), the St. Joe portal (station 9), and the 6850 portal (station 7). Flow at the 6850 and 7400 portals accounted for about 95 percent of the total discharge from the three portals for 1976. An undetermined amount of water flowed from the 7200 portals during late summer, 1976, when a caved portion of the adit was removed and ponded water flowed out.

Evaluation of Water Movement for Levels 7300 through 6600

Flow at the 6850 portal includes drainage from the 7300 through 6850 levels, discharge from diamond drill holes, and artesian discharge from the Pierce Winze. The total discharge from the 6850 portal was approximately 63 acre-feet for the 1976 water year. Since the mine is currently inactive, this drainage must come from intercepted ground-water flow systems and flow systems created by the mine workings.

Ground water which discharges to the mine workings comes from faults and fractures, diamond drill holes, and the Pierce Winze. Water from faults and fractures drains to the lowest point on that level and then to the next lower level through the many open raises and ore passes which connect the levels. Barricades have collapsed on some levels allowing saturated sand fill to flow

into the main drift from stoped areas. This loss of sand fill provides additional flow paths for water as well as removing support from that portion of the mine.

In one area of the mine, flow on two levels moves toward a common discharge point within the mine workings. This occurs on the 7300 and 7200 levels in the vicinity of the Brown Bear Shaft (Plates IA and IB). The Brown Bear Shaft receives ground-water flow from these two levels and discharges the total flow to the 7100 level. This water then flows along the 7100 level to the 616 raise (616 R) where it discharges to the 6850 level. Levels in the vicinity of the 616 R (Plates IA and IB) also contribute ground-water discharge to this raise.

Discharge from the 616 R was monitored on the 6850 level during the 1976 field season (station 68616, Figure III-5). The base flow component of discharge was estimated by applying base flow separation techniques to the hydrograph of station 68616. A horizontal line was drawn from the point where the rising limb started to the point of intersection with the falling limb of the hydrograph. This base flow component represents ground-water contribution and was estimated to be 7 acre-feet for 1976. Several other raises contribute varying amounts of ground-water discharge to the 6850 level, but measurement of these sources was not possible. Considering these additional sources, the total amount of ground-water discharge from the 7300 through 7000 levels is probably 10 to 12 acre-feet per year. This volume of ground-water discharge cannot be reduced without major sealing of the underground workings.

Diamond drill holes contribute ground-water flow to the 6850 level drainage. Diamond drilling was conducted as drifting advanced in the mine workings. This drilling encountered ore bodies in addition to the saturated

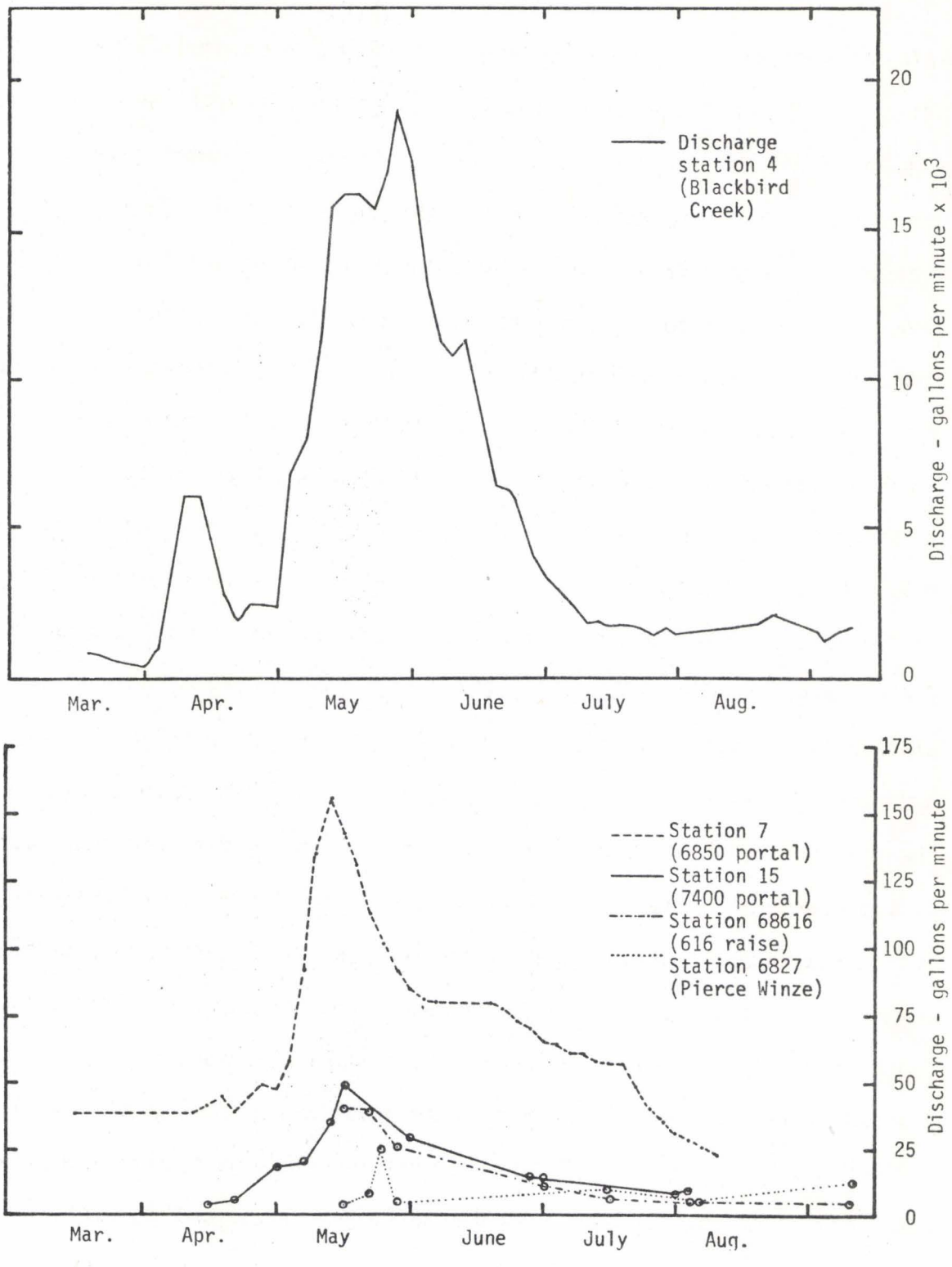


Figure III-5. Discharge hydrographs for stations 4, 7, 15, 68616, and 6827 for 1976.

faults and fractures. Ore bodies in the Blackbird District are emplaced in faulted shear zones and commonly receive surface-water recharge. Drill holes intersecting these features provide a constant source of discharge to the underground workings. During the course of the field investigations, it was noted that twenty diamond drill holes contributed 16 acre-feet per year to the 6850 drainage as measured in 1976. This source of ground-water discharge could be eliminated by grouting or capping the flowing drill holes.

Artesian flow from flooded levels below the 6850 discharges at the Pierce Winze (station 6827). The hydrograph at station 6827 for 1976 is shown in Figure III-5. This discharge contributes a volume of 10 acre-feet per year to the 6850 level. This source of ground-water discharge probably cannot be eliminated. Total discharge-modified and mining-modified ground-water discharge from levels above the 6850, diamond drill holes on the 6850 level and the Pierce Winze amounted to about 33 acre-feet for 1976.

Evidence of mining created flow systems in mine workings is presented in Figure III-5, which shows hydrographs for one surface and four underground discharge stations. The similarity of hydrographs for stations 4, 7, 68616, and 15 shows that recharge from snowmelt appears in the mine workings with very little lag time. The hydrograph for station 6827 is also presented in Figure III-5. This hydrograph appears to lag hydrographs at stations receiving surface recharge. Recharge to ground-water flow systems moves slowly through long flow paths. Discharge from such a flow system should therefore lag behind direct surface-water discharge.

Additional evidence of mining-created flow systems in underground workings is seen in Figure III-6 where water temperatures at four underground stations are presented. Three stations with surface recharge show a drop in water

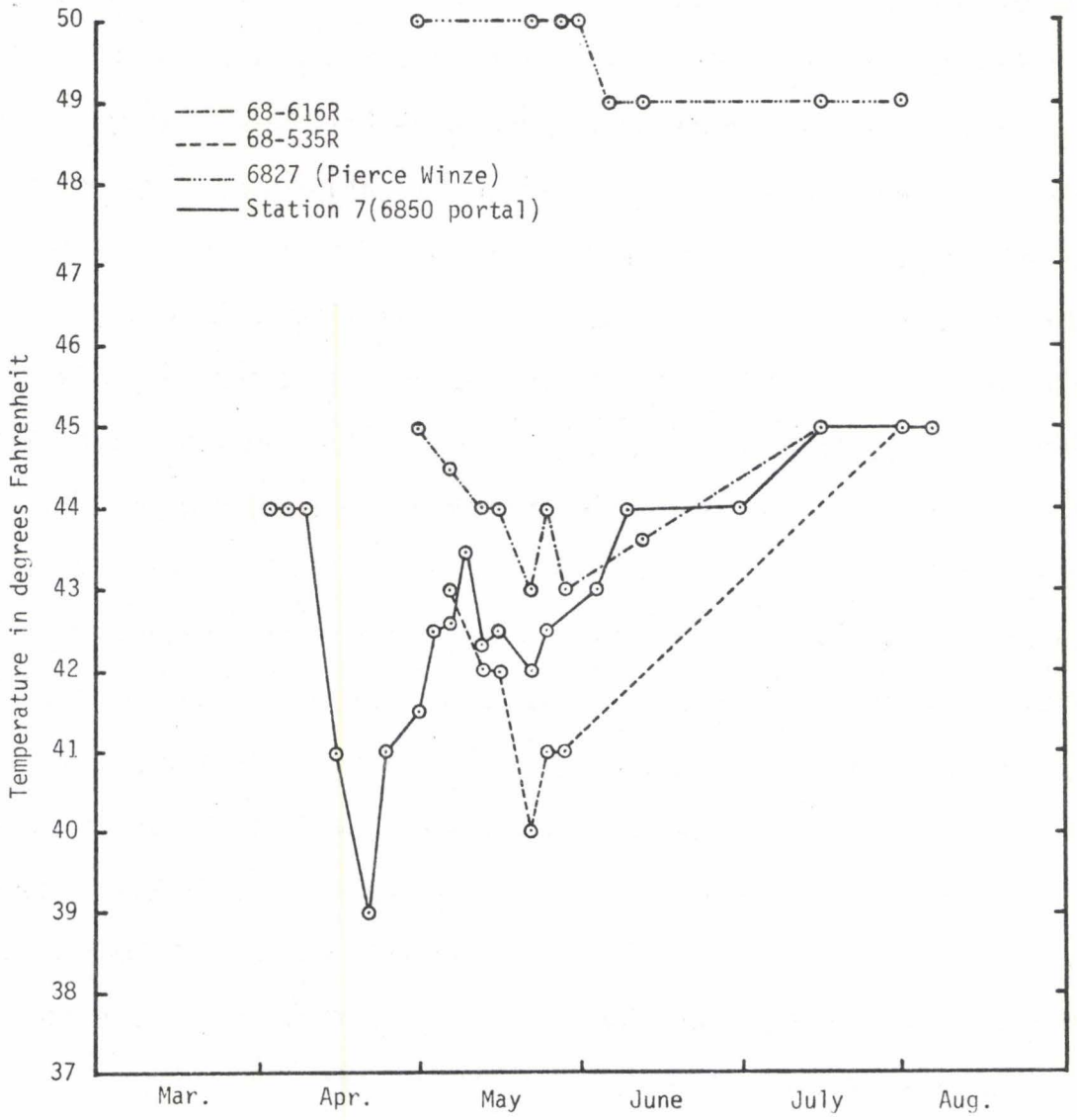


Figure III-6. Variations of water temperature at stations on the 6850 level for 1976.

temperature as cold water from melting snow enters flow systems in the mine workings. Water temperatures at station 6827 (Pierce Winze) indicate that this discharge comes from a system with a long retention time and warmer temperatures, such as a ground-water flow system.

Measurement of mining-created recharge to mine workings was limited to discharge measurements at station 68616 and discharge estimates at station 68535 (535 raise). The hydrograph at station 68616 is a combination of discharge-modified and mining-modified ground-water discharge and mining-created discharge. For simplicity, discharge-modified and mining-modified ground-water discharge will be referred to as ground-water discharge and mining-created discharge will be referred to as surface-water discharge. The total discharge at station 68616 was estimated to be 12 acre-feet for 1976. The ground-water component of discharge previously calculated was 7 acre-feet. By subtracting the ground-water component from the total discharge, a volume of 5 acre-feet was calculated as surface water which discharges at station 68616. This volume of water should be considered a minimum discharge value. Discharge at station 68535 was estimated by comparison with station 68616. A hydrograph constructed from these estimates gave a total volume of about 5 acre-feet. This discharge occurred between May 1 through July 30, 1976, and is believed to represent almost entirely surface-water recharge (mine-created flow systems) to mine workings. Temperature variations at this station (Figure III-6) show the effects of recharge from snowmelt water. Total surface water estimated at station 68616 and 68535 is therefore 10 acre-feet.

The total measured volume of discharge to the 6850 level was about 43 acre-feet for 1976. This amounts to 70 percent of the total discharge at the 6850 portal (station 7, Table III-3). The remaining 30 percent or 20

Table III-3. Discharge of analysis of the 6850 level for 1976.

Parameter	Station		Discharge (acre-feet) Subtotal	Total
Discharge-modified[a] and mining-modified[b] ground water (from baseflow separation)	All sources		43	43
Ground water	68616	7		
Ground water	6827	10		
Ground water	Diamond drill holes	16[d]		
		33	33	
Ground water	Unmeasured sources		10	
Mine-created[c] surface water (from baseflow separation)	All sources		20	20
Surface water	68616	5[d]		
Surface water	68535	5[d]		
		10	10	
Surface water	Unmeasured sources		10	
Total discharge	7 (6850 portal)			63

[a] Pre-mining ground-water flow systems modified by the relocation of discharge areas

[b] Pre-mining flow systems modified by mining or exploration by changes in recharge and/or discharge areas

[c] Discharge from mine portal which has entered the mine directly through openings such as raises or open pits

[d] Discharge volume which could be reduced or eliminated.

acre-feet of discharge is probably equally divided between surface- and ground-water discharge. From Table III-3, it is seen that during 1976 about 26 acre-feet of discharge may be reduced or eliminated. This was about 40 percent of the total discharge at the 6850 portal. Finally, from Table III-3, it is seen that about 30 percent of the total discharge at station 7 (6850 portal) is from direct surface-water recharge to the mine workings and 70 percent of the total discharge is from ground-water discharge to mine workings.

The accuracy of this discharge analysis depends on the amount of data available at the various stations. A good hydrograph is available for station 7 (6850 portal) during the 1976 field season and errors caused by extrapolating the hydrograph over the remainder of the year should be small. Therefore, the total discharge at station 7 is probably within 10 percent of the actual discharge. Data are less accurate for stations within the mine workings where only occasional discharge data were collected. However, wide fluctuations in discharge do not occur at these stations and extrapolations between data points should be fairly accurate. Discharge data for stations 68616 and 6827 are probably within 25 percent of the actual discharge.

Evaluation of Water Movement for Levels 7400 and Above

Discharge at the 7400 portal (station 15) includes drainage from the 7400 through 7675 levels. Sources of this drainage include discharge-modified and mining-modified ground water as well as mining-created flow to mine workings. Total discharge from the 7400 portal was about 15 acre-feet for the 1976 water year. Field observations show that there is little direct flow down raises connecting the 7400 and 7300 levels. However, raises extending up from the 7300 and 7200 levels apparently receive mining-modified and discharge-modified flow from fractures or faults above the 7300 foot elevation.

During high runoff periods, larger volumes of water could be expected to discharge to these raises and subsequently to the 6850 level. Therefore, some hydrologic connection between areas above and below the 7400 and 7300 levels is probably present.

Base flow separation indicates that 9 acre-feet of the total 15 acre-feet discharged at station 15 (7400 portal) was from ground-water discharge from discharge-modified and mining-modified flow systems. Only one flowing diamond drill hole was noted on the 7400 level.

Evidence of mine-created recharge to levels 7400 and above can be seen from the hydrograph for station 15 (Figure III-5). The figure shows that recharge to the workings is direct. By subtracting baseflow from the total discharge, the volume of mine-created (surface-water) recharge to these workings was found to be 6 acre-feet or 40 percent of the total discharge. It is believed that very little of the water discharging at station 15 can be reduced or elimiated.

Sources of Recharge to Mine Workings in the Blackbird Creek Drainage

It has been shown that a significant amount of the total discharge at station 7 and a lesser amount of the total discharge at station 15 is due to mine-created recharge to mine workings. Identification of possible recharge areas is needed before reduction or elimination of surface-water recharge can be accomplished. Mine-related surface features which allow surface water to directly recharge underground workings include raises intersecting ground surface, surface disturbed areas and open pits areas. Raises intersecting the ground surface are normally covered to prevent direct surface-water recharge. However, some raises were inadequately sealed or not sealed

at all. Raises may connect only two levels or they may connect several levels. An unrestricted flow path is created in the case where a raise extends from the ground surface to the 6850 level with little offset between levels. Four such flow paths were tentatively identified based on observed discharge from raises on the 6850 level. Discharge from the 518, 535, 616, and 689 raises on the 6850 level show an increase with spring runoff. Plate I shows that these raises do extend from the 6850 level to the surface. Plate I also shows that the 706 vent raise (706VR) extends from the 7100 level to the ground surface. This raise was not accessible on the 7100 level and therefore discharge was not monitored, but surface water can easily enter the raise. A circular opening about 20 feet in diameter marks the intersection of this raise with the ground surface. This opening lies near the botton of a small draw which carries runoff water during the spring months.

Surface water may also enter underground workings through mining-modified ground-water flow systems. Some 60 trenches and shallow pits were developed during exploration and mapping of geologic structures in the mining area. Many of these features are located on surface expressions of fault and fracture zones. Water collects in these trenches from precipitation and runoff and infiltrates the more permeable zones. Many of these zones lead directly to underground workings. It is estimated that recharge to underground workings from this source amounts to about 10 percent of the total discharge at station 7.

Surface water may also reach underground workings through mining created fracturing. Removal of ore from workings close to the ground surface causes stress on the overlying material. This stress can result in mine-related fractures. Surface water from spring snowmelt can enter these fractures and discharge to mine workings. This type of recharge to mine workings may total 10 percent of the total recharge at station 7.

An estimated 75,000 feet of surface diamond drilling has been completed in the mining area. This type of drilling is aimed at reaching ore bodies, which are usually more permeable than the surrounding rock. This type of exploration increases recharge to the ground-water flow systems by providing more interconnections between the surface and subsurface. To investigate the potential interconnection, a 400:1 water-dye mixture (Rhodamine WT dye, 20% concentration) was injected in selected surface drill holes during the 1975 and 1976 field seasons. Seven diamond drill holes were chosen for this tracer experiment during the 1975 field season. These holes lie directly east of the 7100 portal between 7,650 and 7,675 feet elevation. The holes lie on a southwest-northeast line with the two farthest holes about 600 feet apart. Drill logs were only available for one of the seven drill holes, S-126. This hole was drilled to a depth of 625 feet. Figure III-7 shows that this drill hole penetrates several ore bodies and fault zones before terminating about 50 feet above the 7100 level. All drill holes had a diameter of about 3 inches. About 100 gallons of the water-dye mixture was added to each of the seven drill holes on August 8, 1975. All seven holes accepted the tracer solution readily. Discharge from underground workings nearest the drill holes was monitored for two weeks following the injection. Fluorometric analysis and visual inspections showed that none of the tracer solution appeared in mine discharge. It was felt that insufficient water was injected in the drill holes and that this volume of water was dissipated over the long distance between holes.

A second tracer experiment was conducted during the 1976 field season using drill holes S-126. In this attempt, the water-dye solution was injected into the hole for a period of one hour on July 22. A total volume of about

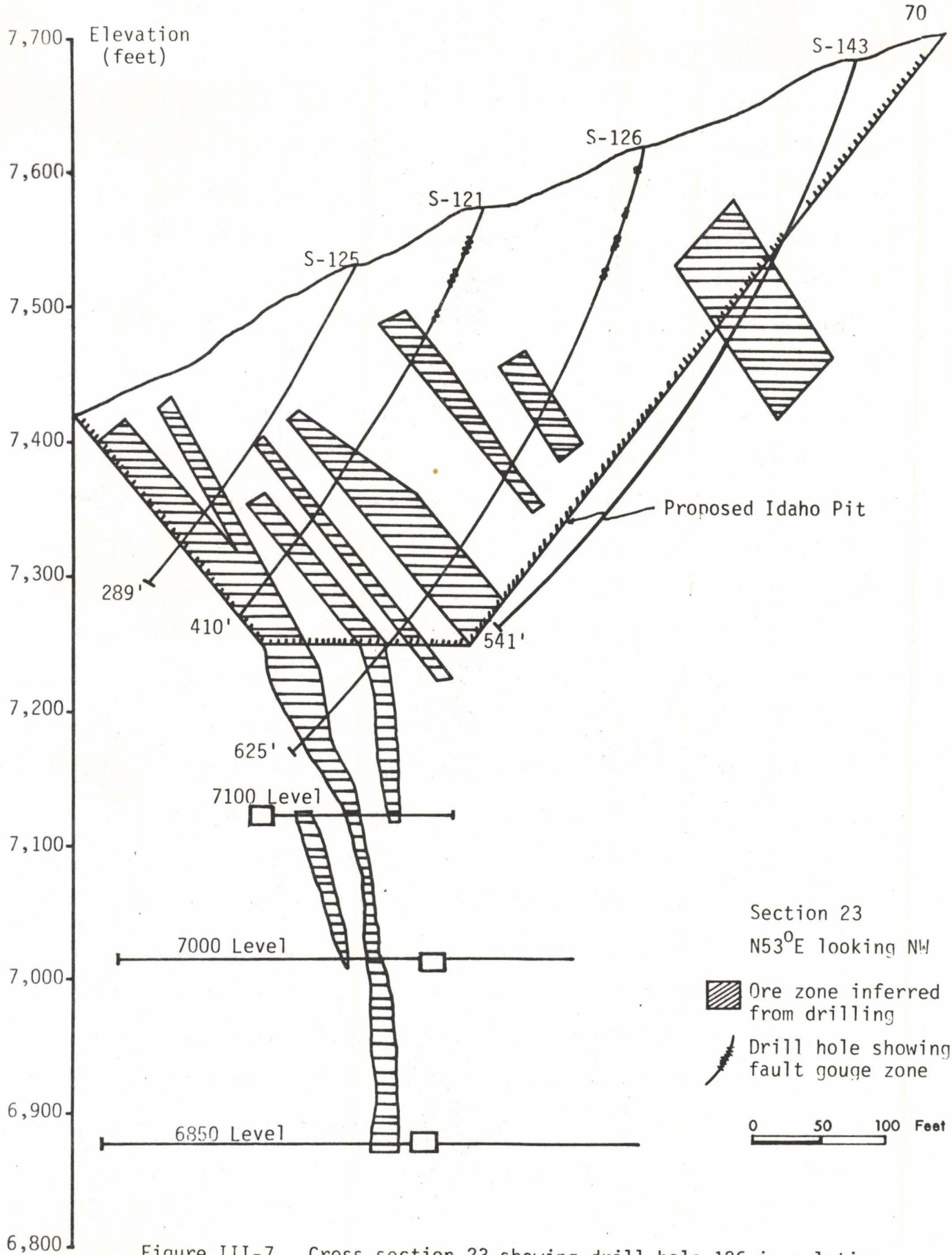


Figure III-7. Cross section 23 showing drill hole 126 in relation to mine workings.

600 gallons was injected in this drill hole. Again, fluorometric analysis and visual inspections of the mine discharge showed that none of the tracer discharged to mine workings during a two week monitoring period.

The results of these two tracer experiments provide some information on the role surface diamond drill holes play in mine recharge. First, it is doubtfull that sufficient water was used in either experiment to fully saturate the test areas to move the solution into mine workings. Second, the dip of the ore bodies in this area would tend to divert any recharge away from the 7100 level. Lower levels might receive the tracer solution but after longer time periods. Third, in both tracer attempts, the solution was injected during late summer months when ground-water flow systems normally saturated by spring runoff would be dry. Had the experiments been carried out during spring runoff, the tracer might have entered active flow systems and been directed toward underground discharge points. Fourth, the amount of surface recharge entering any of the drill holes may be quite small. All holes were plugged after drilling with wood plugs, and those holes inspected appeared to be well sealed against surface-water intrusion. In addition, some of the drill holes have undoubtedly sloughed in and are not open to their original depth. Ground water entering any open holes is still freely transmitted to flow systems deeper in the mountain.

Recharge from Meadow Creek to mine workings is another potential source of water in the mine. During the course of underground investigations, it was noted that faults, fractures and raises on the 7100 level northwest of the 7100 portals consistently discharged water to the level while similar structures east of the portal were essentially dry. Figure III-8 shows the cross-sectional relationship between Meadow Creek and mine workings in

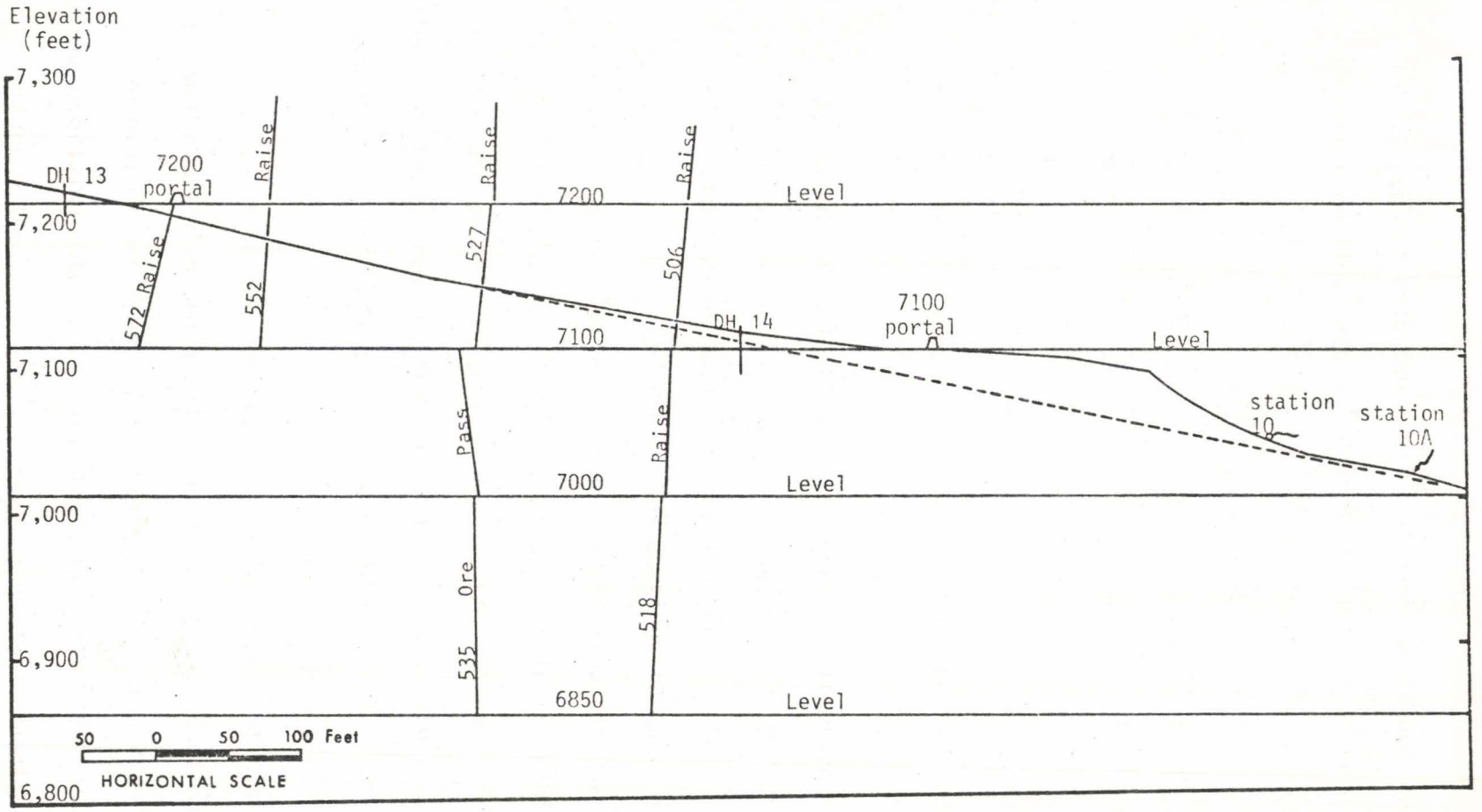


Figure III-8. Cross sectional relationship between Meadow Creek and mine workings in the vicinity of the 7100 and 7200 portals.

the vicinity of the 7200 and 7100 portals. The workings on the 7100 level northwest of the portal are below creek level. A similar situation exists on the 7200 level, where workings northwest of the 7200 portal are below creek level. Faults and fractures connecting mine workings and Meadow Creek provide an avenue for recharge. Vertical distances of up to 275 feet between the 7100 level and Meadow Creek at station 14 would provide ample head to drive ground water down along permeable zones. Northwest of the 7200 portal, raises extend upward and intersect the ground surface. These raises could easily dewater colluvium and fault zones saturated from snowmelt runoff. Rock units in this area dip 30^{o} to 60^{o} NE from Meadow Creek to the mine workings. Water movement along the dip slope of the beds is probably small due to low porosities and hydraulic conductivities of this material. The amount of water moving in this manner from Meadow Creek to mine workings is difficult to measure. One possible measurement method would be a gain-loss study of Meadow Creek along the reach where recharge to mine workings is suspected. However, discharge data in Appendix III-2 show that during the spring runoff period Meadow Creek is a gaining stream between stations 13 and 10A, and therefore any stream recharge to mine workings could not be detected by this technique. Water level data from piezometers near station 10B (to be presented later) show that this area of the valley floor was a recharge zone. Therefore, the increased stream-flow in Meadow Creek between stations 13 and 10A must have been from surface runoff and shallow ground-water flow from spring snowmelt. It is believed that recharge to mine workings from Meadow Creek represents less than 5 percent of the total discharge at station 7.

Water discharging to the 7200 level should normally flow out the 7200 portal but the portal was blocked by a small cave-in until mid-1976. Water

ponded up behind the cave-in until it reached a sufficient depth to flow down raises to the 7100 level. One such raise was the 572R, which connects the 7200 and 7100 levels in the vicinity of the 7200 portals (Plate I). This raise is partially filled with ore and water flowing down the raise leaches out metal ions. On May 28, 1975, underground investigations on the 7100 level showed that this raise was discharging about one gpm. Two weeks later, peak runoff was occuring and investigations on the 7100 level showed this raise was discharging about 20 gpm. Analysis of a sample of this discharge (station 7114, Appendix II-1) showed that the metal load was 8 pounds per day of cobalt, 11 pounds per day of copper, and 5 pounds per day of iron. During the latter part of the 1976 field season, the cave-in was removed from the 7200 portal and mine drainage flowed out the portal and into Meadow Creek. This maintenance work resulted in a reduction in cobalt, copper and iron loads at station 7 by 15, 10 and 5 percent, respectively.

Water Quality in Mine Workings in the Blackbird Creek Drainage

Distinct water types within the mine workings can be recognized based on water quality differences. These water quality difference exist because of mineralogical and travel time differences for the various sources of recharge to the mine workings. Mine-created flow, water discharging from raises, ground water (water from flooded levels below the 6850), and diamond drill hole water all have differing water-quality characteristics. Water discharging from diamond drill holes can be further subdivided based on whether or not the drill hole encountered an ore body. Table III-4 is a summary of water-quality data for various discharge sources in the underground workings. These data represent averages of samples collected during the 1975 and 1976 field seasons.

Table III-4. Water quality data for different sources in mine workings in Blackbird Creek drainage for the 1975 and 1976 field seasons. (Metal ion concentrations given in parts per million)

Water Source	pH	E.C.	Co	Cu	Fe	Mn	Mg	Ca	Na	Number of Samples
73707 (706 vent raise-surface water)	6.7		-0.1	-0.1	-0.1	-0.1	0.8	3.6		1
6827 (Pierce Winze-ground water)	6.4	770	2.1	-0.1	162.0	3.8	23.4	10.3	7.8	14
Diamond Drill Holes (Ore bodies[a])	4.5		17.7	1.2	242.0	11.1	45.1	21.4	9.9	5
Diamond Drill holes (No ore bodies encountered)	5.0		1.2	0.2	0.4	2.4	2.3	1.5	2.8	5
5 Raises	2.6	2500	23.3	46.9	518.0	25.0	118.0	15.4	4.7	37
6835 (Drainage from back part of 6850)			3.2	1.3	4.2	1.3	6.9	2.0	2.7	1

[a] Ore body has been actively mined

-0.1 less than 0.1

Surface runoff water was sampled at one point in the mine, the 706 vent raise (706VR) on the 7300 level. The water at this sampling station had not yet come into contact with sulfide minerals; therefore the water quality was good. Water at this sampling location is assumed to come from a ground-water flow system in the shallow sediments in the gully where the 706VR intersects the ground surface.

Water flowing from flooded levels below the 6850 was sampled at station 6827. The source of this water is thought to be ground-water flow from faults and fractures. The high iron values indicate that this water comes into contact with sulfide mineralization; however, average pH of this water was 6.4. The flooded nature of this portion of the mine would limit acid production. Solubility relationships show that at these high pH values, most of the iron must exists as Fe(II) or $Fe(OH)_2$.

Water quality data for five diamond drill holes which did not encounter ore are shown in Table III-4. The quality of this water is good, with very little cobalt, copper, and iron detected in the samples. Water discharging from these drill holes probably follows faults and fractures.

Water discharging from diamond drill holes which penetrate ore bodies is lower in pH and higher in dissolved metals than water from diamond drill holes which do not penetrate ore bodies. Water percolating through the ore bodies promote pyrite oxidation and removes metal ions from the oxidation sites. In addition, active mining of the ore bodies exposes pyrite minerals to atmospheric conditions which enhances the oxidation process. Water from drill holes penetrating ore bodies which have been mined is higher in dissolved metals and has low pH. Five samples were taken from diamond drill holes where an ore body was encountered but had not been mined. The quality of this water was intermediate between the previous two water types.

A total of 37 water samples were collected from raises discharging water to the 6850 level (Table III-4) during the 1976 field season. This water has the lowest pH and highest metal concentrations of any of the water types identified in underground discharge points. This water type results from the most favorable conditions for production of acid water. Large amounts of ore-rich materials in raises, stopes, and drifts are exposed to atmospheric conditions and oxidation products are removed by water. Increased flow through mine workings during spring runoff flushes oxidation products from areas not normally in contact with water. Numerous pools of acid water also collect in the mine during low flow periods. The influx of water during spring runoff can flush out these pools, adding additional poor quality water to the system.

One water sample was collected at sample station 6835 (Plate I) during the 1975 field season. Most active mining on the 6850 level has taken place in areas downstream of this sample station. All water upstream of this station comes from diamond drill holes or fractures, and water quality at this station reflects this fact. The sample had only small concentrations of metal ions, compared to downstream stations (sample station 6835, Appendix III-1).

The chemical processes of acid production are considered to be the same for both underground and surface situations. One variable which favors increased acid production in underground workings is greater exposure of sulfide minerals to atmospheric conditions. Stopes, drifts, cross-cuts, ore chutes, and raises all expose ore material to oxygen. The limiting factor on acid and heavy metal production from underground workings is the lack of water to carry away oxidation products; the Blackbird Mine is a relatively "dry" mine.

Variations in metal ion concentrations for underground workings are very similar to variations observed at surface waste features. Figures III-9 and 10

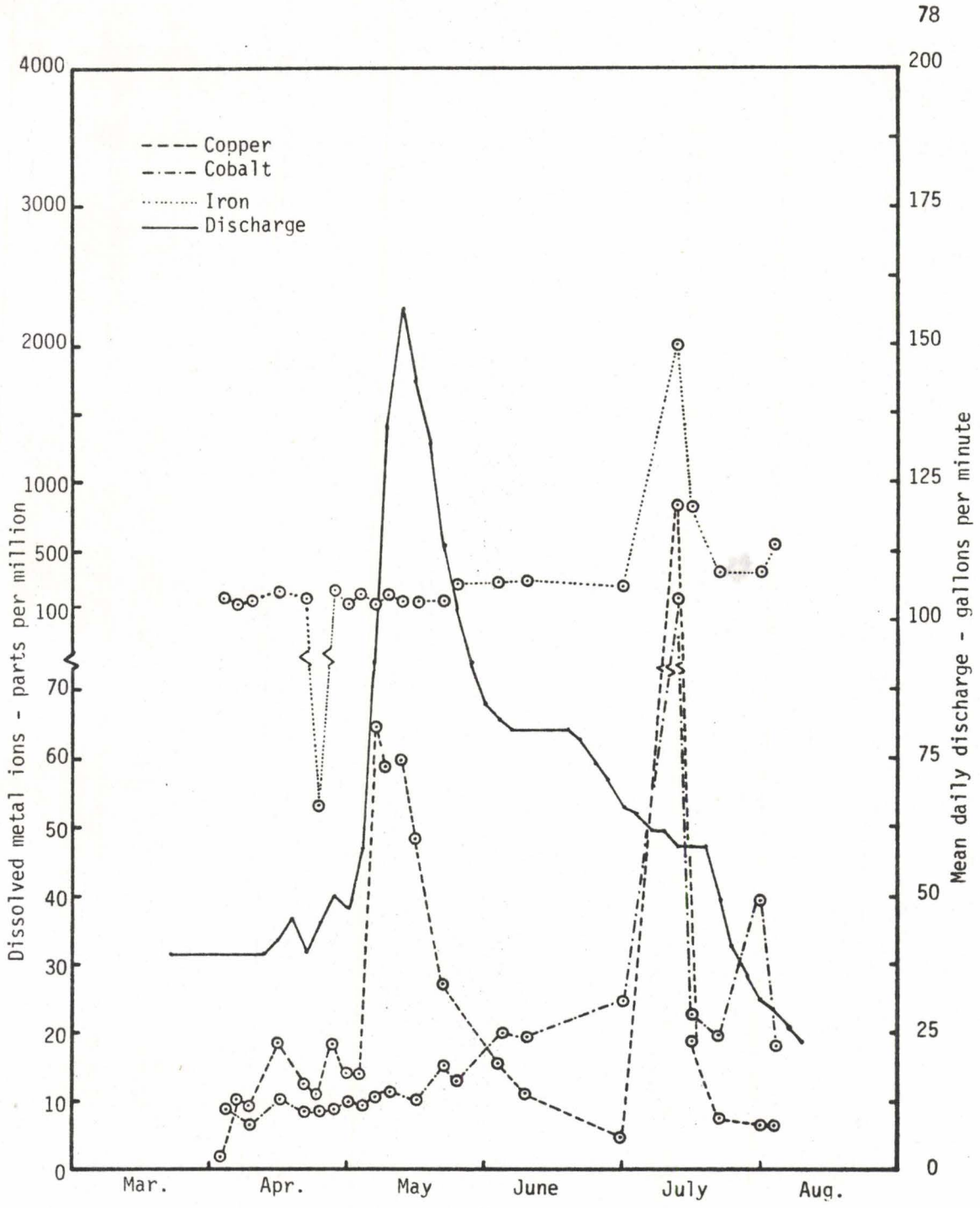


Figure III-9. Dissolved cobalt, copper, and iron concentrations at station 7 (6850 portal) for 1976.

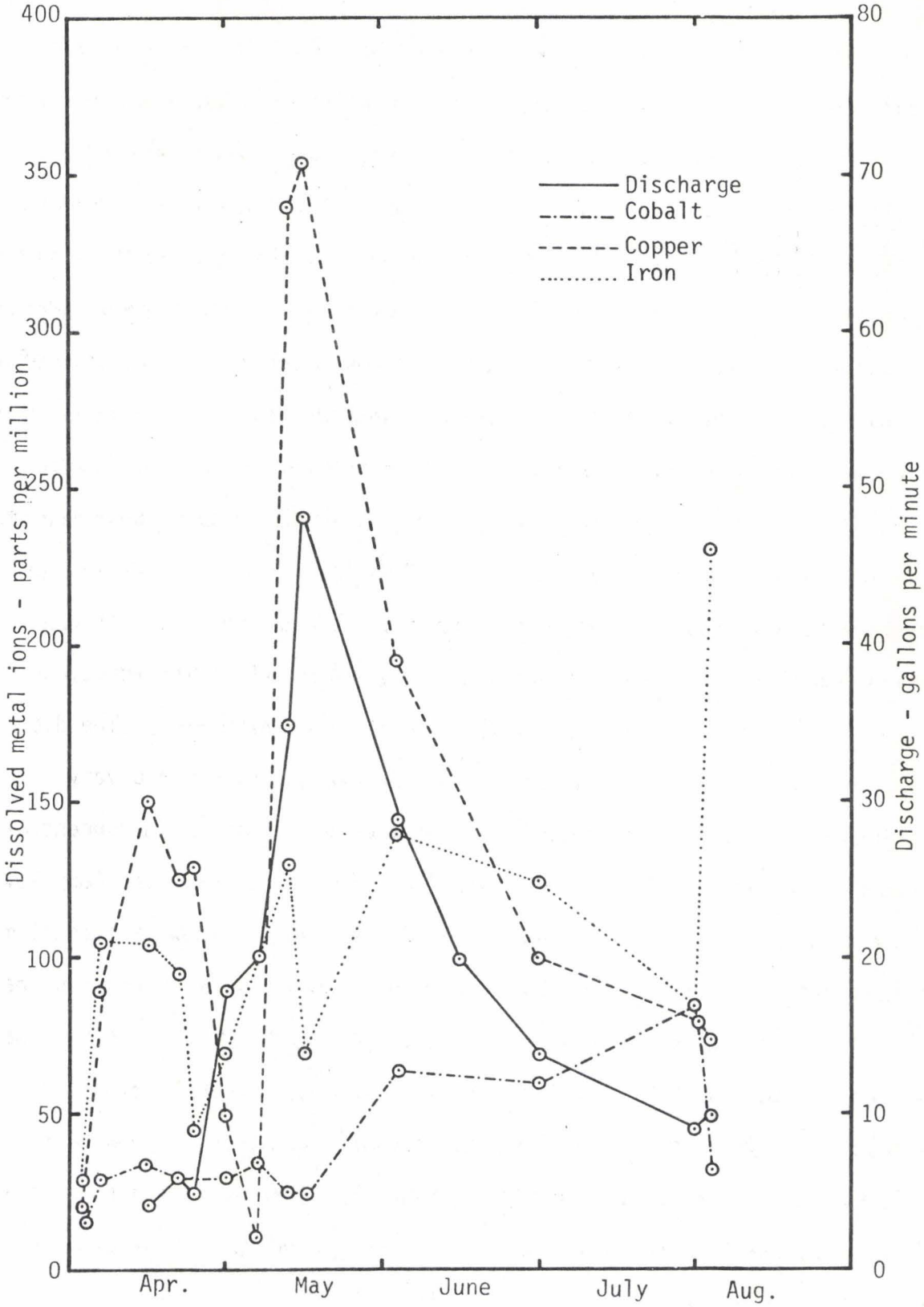


Figure III-10. Dissolved cobalt, copper, and iron concentrations at station 15 (7400 portal) for April to August, 1076.

show metal ion and discharge variations for station 7 and 15 (6850 and 7400 portals) for 1976. Discharging raises on the 6850 level show similar metal ion variations with flow. As with surface waste features, runoff water entering mine workings flushes away accumulated oxidation products resulting in increased metal loads from underground discharge points during high runoff. Oxidation products begin to accumulate as soon as the spring runoff water recedes. This accumulation process continues until a surge of water again passes through the mine, transporting the acid salts away. Run-off from late summer thunderstorm activity may transport metals from the mine during the low-flow period. This process is believed to have caused the peak in metal-ion concentration seen in mid-July on Figure III-9. Figure III-10 shows that a peak in metal-ion concentrations occurred at station 15 during mid-April of 1976. This peak resulted from the first introduction of snowmelt into the mine workings during the 1976 runoff period. The discharge hydrograph for station 15 (Figure III-10) shows that only a very small volume of water was necessary to bring about high metal ion concentrations during mid-April. Downstream variations of metal ions on the 6850 level are shown on Figures III-11 through III-14. These figures show that total metal ion concentrations increase with downstream position in the main ditch as each source contributes its share of acid and metal ions. The data also show that downstream of station 6824, dissolved metal ion concentrations decrease, indicating that dissolved metals begin to form precipitates but remain in suspension and are transported out of the mine. The precipitation of dissolved metals may results from the addition of relatively good quality water from diamond drill holes downstream of station 6824.

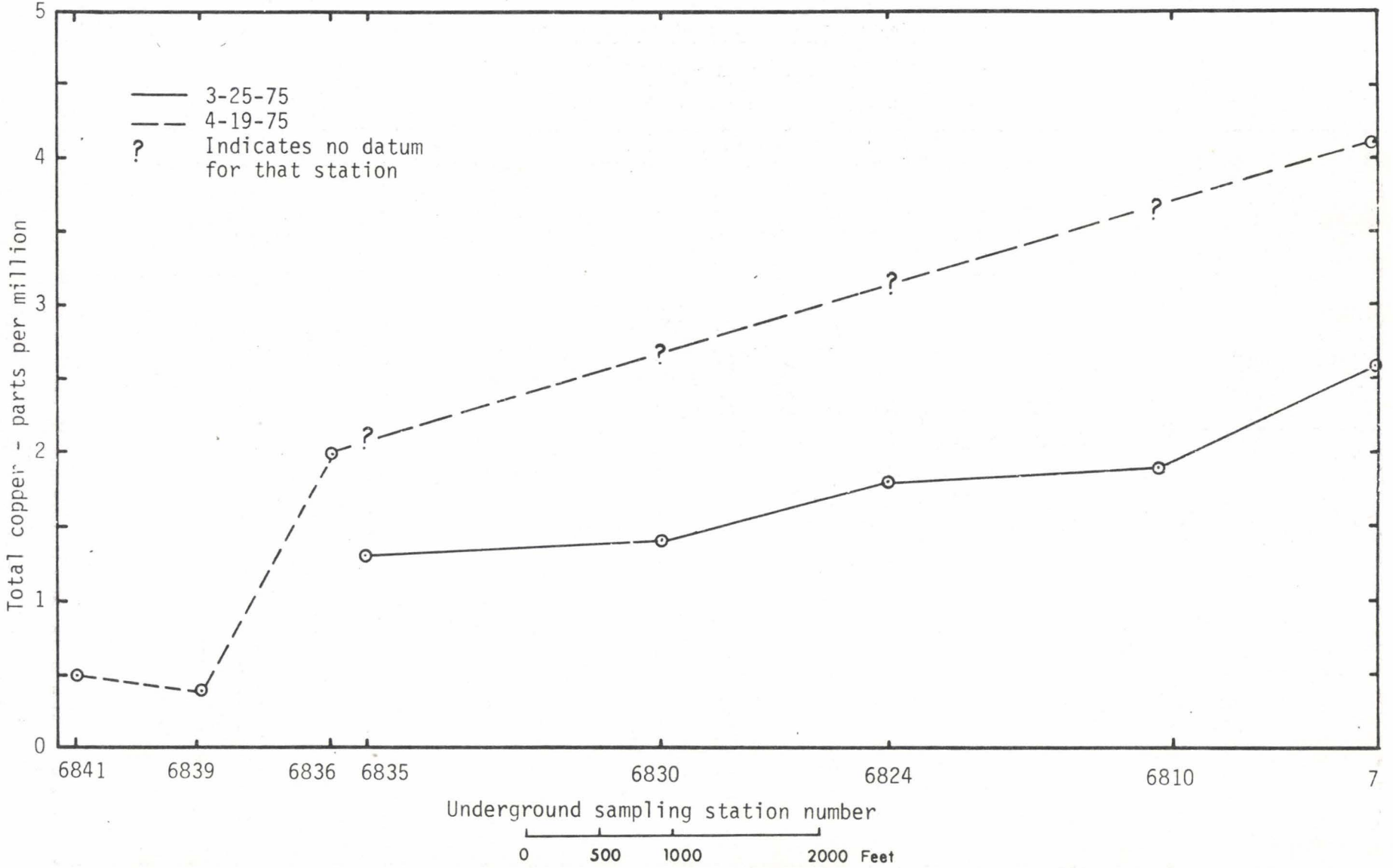


Figure III-11. Downstream variations in total copper for the 6850 level, 1975.

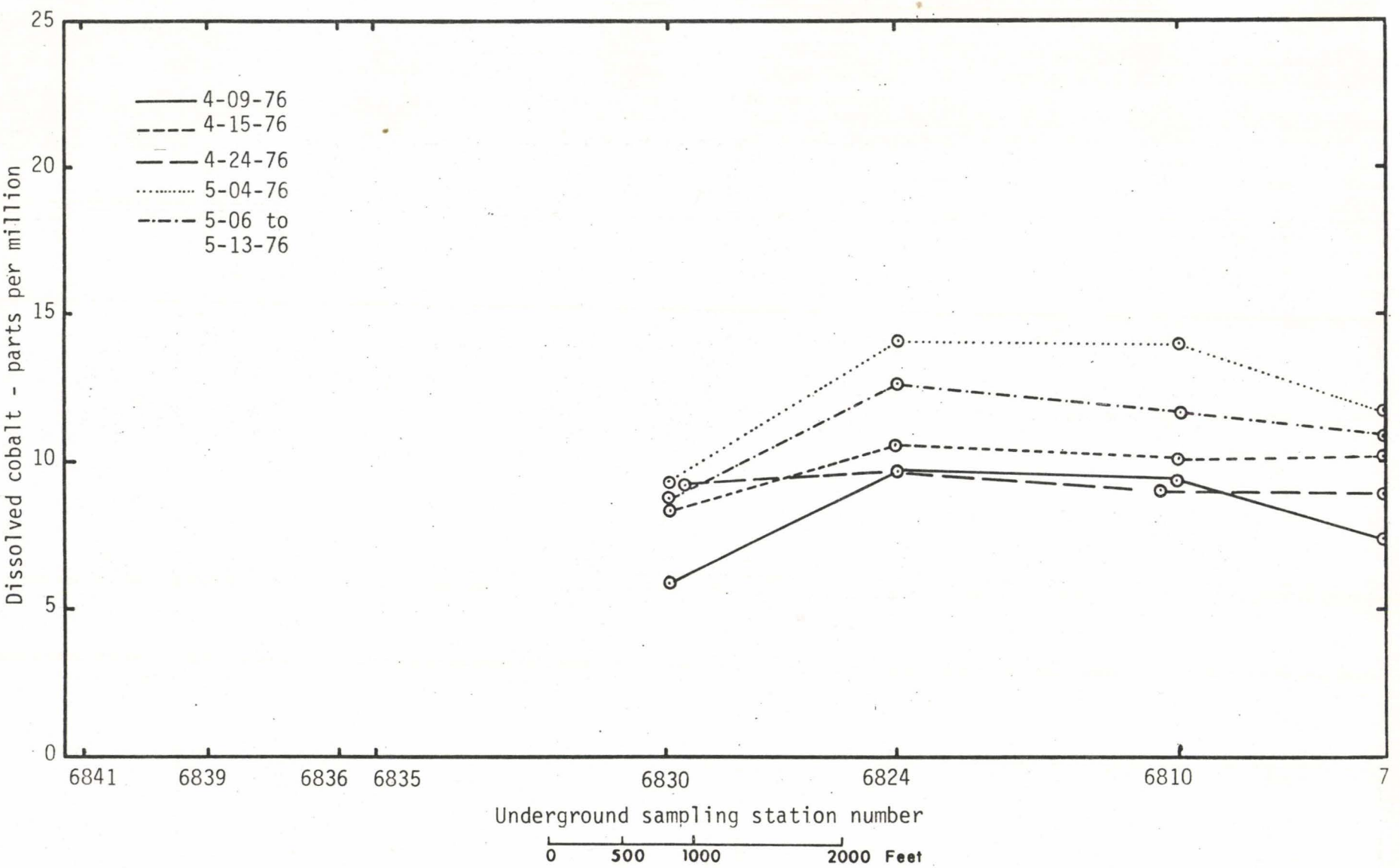


Figure III-12. Downstream variations in dissolved cobalt for the 6850 level, 1976.

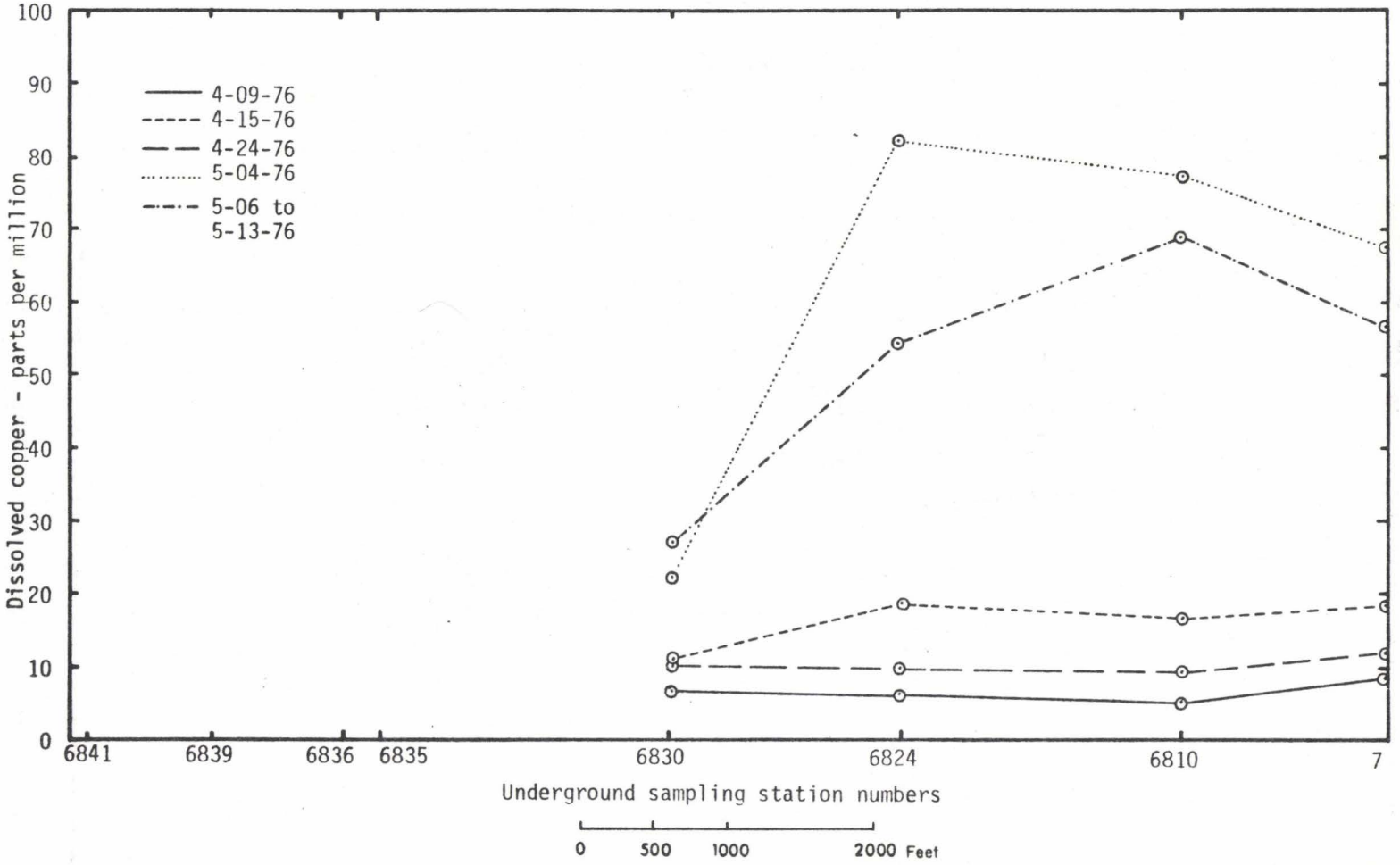


Figure III-13. Downstream variations in dissolved copper for the 6850 level for 1976.

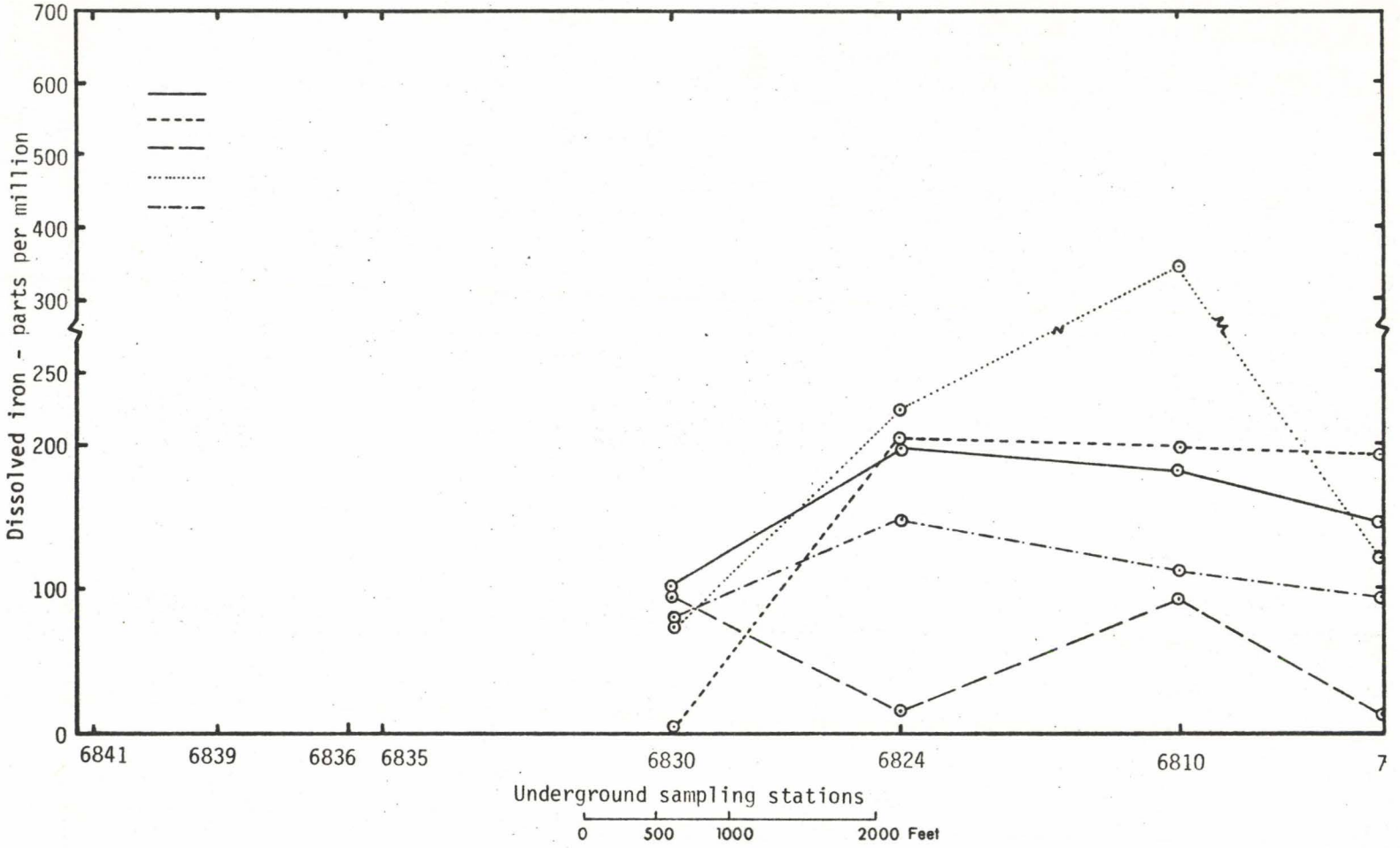


Figure III-14. Downstream variations in dissolved iron for the 6850 level for 1976.

Water discharging at stations 7 and 15 represents the majority of all point source acid discharge from underground workings in the Blackbird Creek drainage. Table III-5 gives metal loads at stations 7, 9, and 15 for various periods from 1969 through 1976. Sample collection was not conducted during winter months but projected water quality and quantity parameters show that approximately 3,000 pounds of copper and cobalt would have been produced at station 7 for 1976. The data show that station 9 contributes about 1 percent of the metal load from the three portals for the period April 3 to August 3, 1976. The data for stations 7 and 15 are not strictly comparable for the various years of record because of differences in analysis techniques, but variations in metal loads are evident for different years. The amount of water available to transport metals from the mine is probably the major factor which determines total metal loads from year to year.

Ground-Water Quality at Selected Sites in the Blackbird Creek Drainage

During the 1976 field season, five piezometers were installed in four drill holes in the Blackbird Creek drainage to investigate groundwater quality. Locations of the drill holes are shown in Figures II-1 and II-2, and construction details for the piezometers are shown in Plate II. Average values for pH, E. C., and metal ion concentrations are given in Table III-6.

Drill Holes 3 and 4

Drill holes 3 and 4 monitored water quality along Meadow Creek. Drill hole 3 was located about 300 feet upstream of the 7100 portal. This hole was completed to a depth of 32.4 feet where bed rock was encountered.

Table III-5. Metal load production from underground workings in the Blackbird Creek drainage. (Metal load is total metals except as indicated.)

Station	Period	Metal Load (lbs) Co	Cu	Fe
7 (6850 portal)	2/25 - 9/30/69	3,600	3,400	7,200
7	6/21 - 11/01/71	1,300	1,000	22,600
7	8/04 - 12/31/74	900	300	4,500
7	5/19 - 7/31/75	2,200	5,300	11,700
7	4/03 - 8/03/76[a]	1,600	2,100	21,000
7	1976 Water year[a]	3,100	3,300	
9(St.Joe portal)	4/03 - 8/03/76[a]	60	160	180
15(7400 portal)	2/15 - 9/30/69	2,300	3,200	2,500
15	7/21 - 11/02/74	300	400	200
15	4/13 - 8/03/76[a]	1,000	6,000	1,500

a Metals are calculated as dissolved metal ions

Table III-6. Ground-water quality in the Blackbird Creek drainage during the 1976 field season. (Concentrations are dissolved metal ions in parts per million, except as noted.)

Sample Station Number	pH	E.C.	Co	Cu	Fe	Mn	Mg	Ca	Na	Number of Samples
DH4	5.6	430	7.1	1.2	10.7	2.3	23.1	60.7	16.0	6
13	3.0	500	27.4	26.6	4.9	2.9	31.1	21.8	4.1	1
DH3S	3.9	940	50.5	64.0	5.4	50.0	35.7	3.1	10.2	7
DH3D	6.2	255	3.9	3.1	4.3	2.9	8.3	33.4	8.4	7
10B	3.7	720	7.7	39.9	7.1	2.0	33.0	20.3	4.3	11
DH2	4.0	1110	1.2	1.4	92.3	1.4	11.4	132.0	23.9	7
DH1	3.1	950	14.6	1.6	243.0	4.4	25.4	77.8	19.7	7
100[a]	4.7	760	6.7	1.3	31.6	4.7	82.0	235.0		3
101[a]	3.1	960	7.3	2.3	34.8	3.5	84.8	190.0		3

[a] Concentrations are total metal ions in parts per million.

Two piezometers were installed in the hole; the upper piezometer (3S) was perforated from 9.2 to 13.2 feet below land surface, and the lower piezometer (3D) was perforated from 28.4 to 32.4 feet. A two foot bentonite seal was placed below piezometer 3S but above the perforations on 3D. Water level differences between the two piezometers indicate that the seal was working. Drill hole 4, located about 1,000 feet upstream of DH3, encountered bedrock at 14.7 feet. A piezometer was installed to 14.7 feet, backfilled with silica sand, and perforated along its entire length.

Water quality at drill holes 3S, 3D, and 4 exceeds background water quality of unaffected streams. Table III-6 shows that water quality varies with depth and downstream position in the Meadow Creek drainage. At drill hole 4, water quality in the valley fill material is fairly good. Several explanations may be forwarded for this water quality. Only small quantities of poor-quality water are believed to discharge from the 7400 waste pile. The intermixing of poor-quality stream water with good-quality ground water probably produces the water type observed at DH4. Recharge to the valley fill material from local ground-water flow systems in the adjacent valley slopes would be good quality water. Alternatively, if the 7400 waste pile does contribute significant amounts of poor quality ground water to the valley fill material, then intermixing of good-quality ground water from local flow systems and water from the 7400 waste pile could produce the observed water type. In this case, Meadow Creek might intermix only slightly with the ground-water system in the valley fill.

Water quality at drill holes 3S and 3D is a function of depth, with relatively good quality water occuring in the lower portion of the valley fill, and poor quality water occuring in the upper material. The depth to

which the zone of poor quality water extends is not known, but it is at least 13 feet. This zone may result in part from intermixing of stream and ground water. However, comparison of water quality at station 10B and DH3S (Table III-6) shows that ground water in the upper valley fill material is generally higher in dissolved metals than stream water. The leaching of metals from the saturated upper valley fill material is postulated to explain this difference in water quality. Examination of the Meadow Creek stream profile (Figure III-15) shows that atleast 10 feet of mine-related waste material has accumulated in the vicinity of DH3. The upper zone of poor quality water closely coincides with the mine waste material deposited over the pre-mining alluvium. Very little mine waste material covers the pre-mining alluvium at station 13 and therefore leaching of heavy metals from this segment of the valley fill should be minimal. Comparison of water quality at station 13 and DH4 (Table III-6) shows that stream water has generally higher metal ion concentrations than ground water. This would be expected if the stream is the primary source of metal ions in the ground water. Drill hole 3D monitored water quality in pre-mining alluvial material. Intermixing of water in this material with the overlying poor-quality water produces ground water with small concentrations of metal ions.

Water levels in DH3 and 4 were monitored during the 1976 field season (Figure III-16). The data show a decreasing head potential with depth at DH3, and ground water is therefore moving downward in this area of the Meadow Creek valley. Figure III-15 shows the hypothetical ground-water flow system in the vicinity of the 7100 waste pile. The figure shows that the water table intersects land surface at the lower portion of the waste pile, resulting in the spring discharge monitored at station 10. This discharge

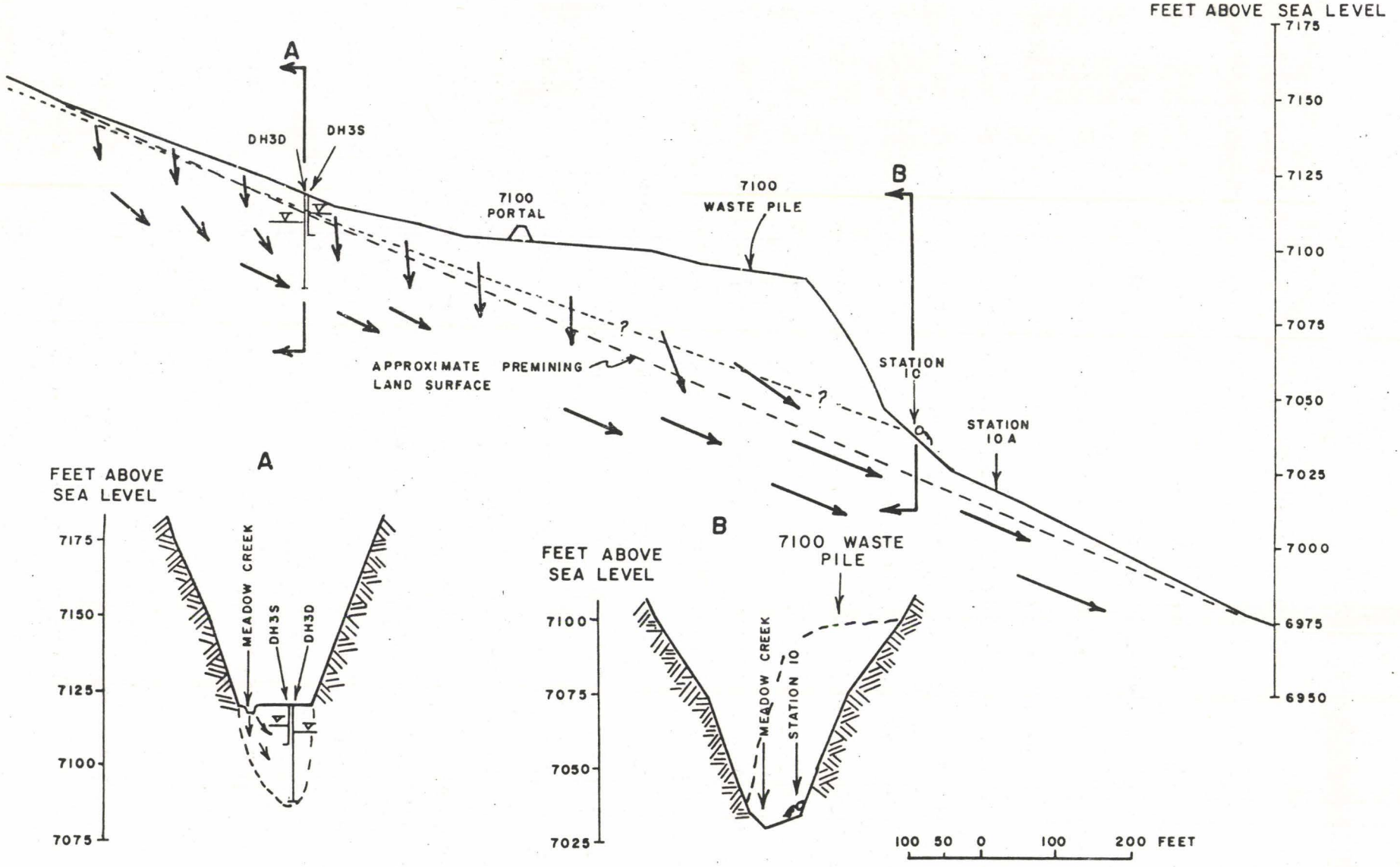


Figure III-15. Meadow Creek stream profile in the vicinity of the 7100 waste pile.

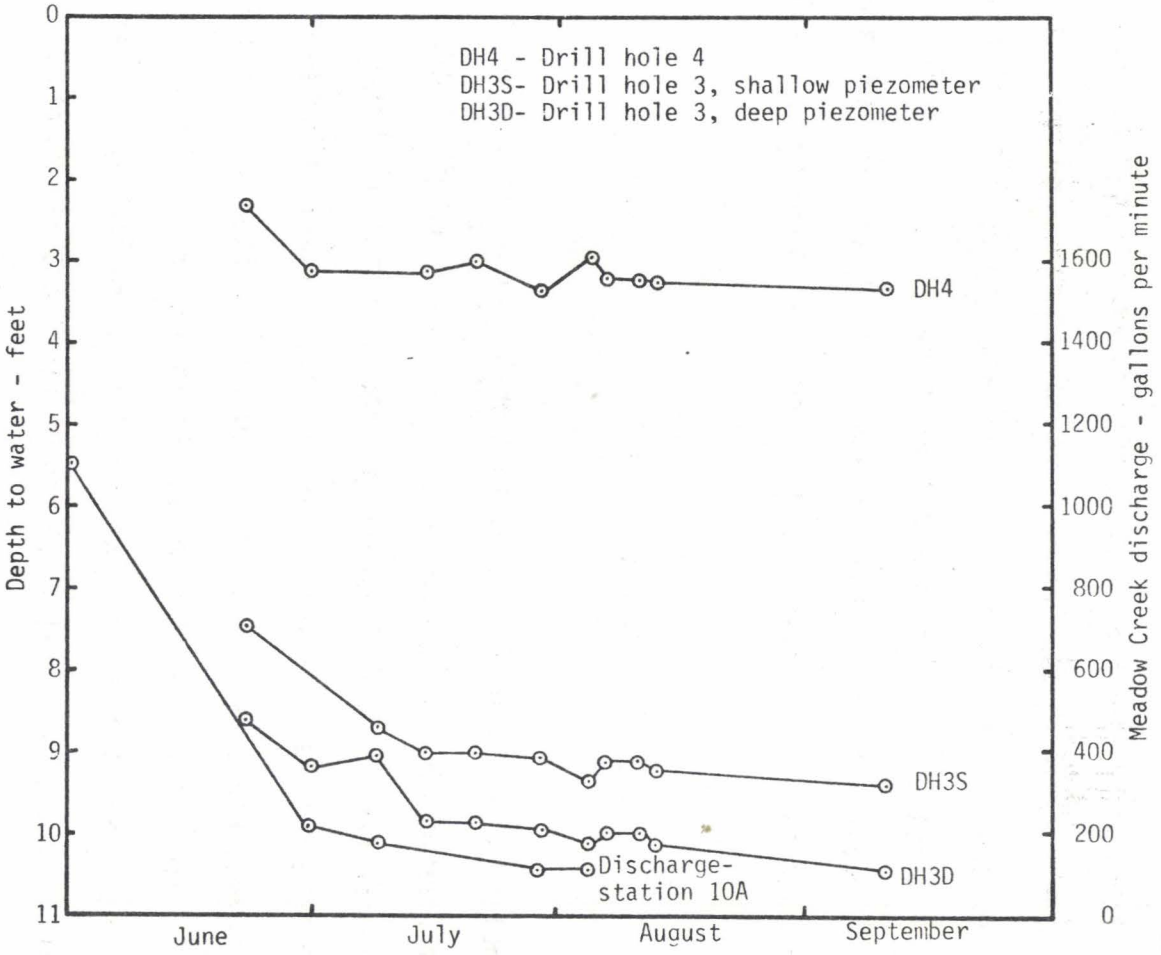


Figure III-16. Water level fluctuations for drill holes 13 and 14, Meadow Creek valley, 1976.

probably represents only a small portion of the total quantity of ground water moving through the mine waste and valley fill material. Additional ground water probably moves down gradient past section B. This ground-water underflow may discharge to Meadow Creek between station 10A and the mill complex. Water levels at DH3S and DH3D mirror each other very closely. Figure III-16 shows that one measurement at DH3D does not follow the general water level trend. This data point is believed to be a measurement error. Stream discharge at station 10A is also shown on Figure III-16; the similarity between water level trends and stream discharge indicates that stream recharge is a major source of ground water in the valley fill material.

Drill Holes 1 and 2

Drill holes 1 and 2 are located at the confluence of Blackbird Creek and the West Fork of Blackbird Creek (Figure II-2). Drill hole 2 (DH2) was placed in the West Fork tailing pile to monitor water quality and ground water levels in the tailings material. The hole was drilled to a depth of 72.4 feet where talus rock was encountered. This talus material represents the pre-tailings land surface. A piezometer with 60 feet of perforations was installed to a depth of 72.4 feet; the drill hole was backfilled with silica sand, and a 0.5 foot bentonite seal was placed at the surface. Analysis of ground water samples shows that copper and cobalt concentrations are low while iron concentrations are high (Table III-6). The milling process returned iron minerals to the tailing material while removing most of the copper and cobalt minerals. High electrical conductivity values for the ground water samples reflect dissolved solids released to ground water as a result of the milling process. The fine grind

necessary for the flotation process increases the rate of dissolution of any soluble minerals contained in the ore. Concentrations of all metal ions was higher than background water quality in unaffected streams.

Drill hole 1 is located at the base of the West Fork tailings pile and was completed to a depth of 16 feet. The material at this location is thought to be mostly natural stream materials. Ground water in this material is higher in dissolved cobalt and iron has lower pH values than ground water sampled in the tailings pile (DH2 in Table III-6). The source of these metal ions is assumed to be ground water discharges from the tailings pile. Increased cobalt and iron concentrations at DH1 may reflect longer flow paths and increased contact with sulfide minerals. Williams (1968, p.7) cites several studies where total dissolved solids in ground water has increased with the length of the flow path. Two springs at the base of the West Fork tailings pile were sampled during 1975. Water quality at these springs, sample stations 100 and 101 (Figure II-2), is intermediate between DH1 and 2. It is believed that this water represents intermixing or poor-quality ground water from the tailings pile and good-quality ground water from local flow systems of the valley slopes. The station directly below the West Fork tailings pile (station 101) had a pH value of 3.1. Station 100 was a spring discharging near the contact of tailings material and the natural valley slope (Figure 11-1). The pH of this water averaged 4.7 and probably reflecting mixing of good-and-poor-quality water.

Metal ion concentrations at the five piezometers in the Blackbird Creek drainage generally increased during the 1976 field season. The dissolved cobalt concentration was taken as a measure of water quality at each piezometer (Figure III-17); concentrations of other metal ions show similar

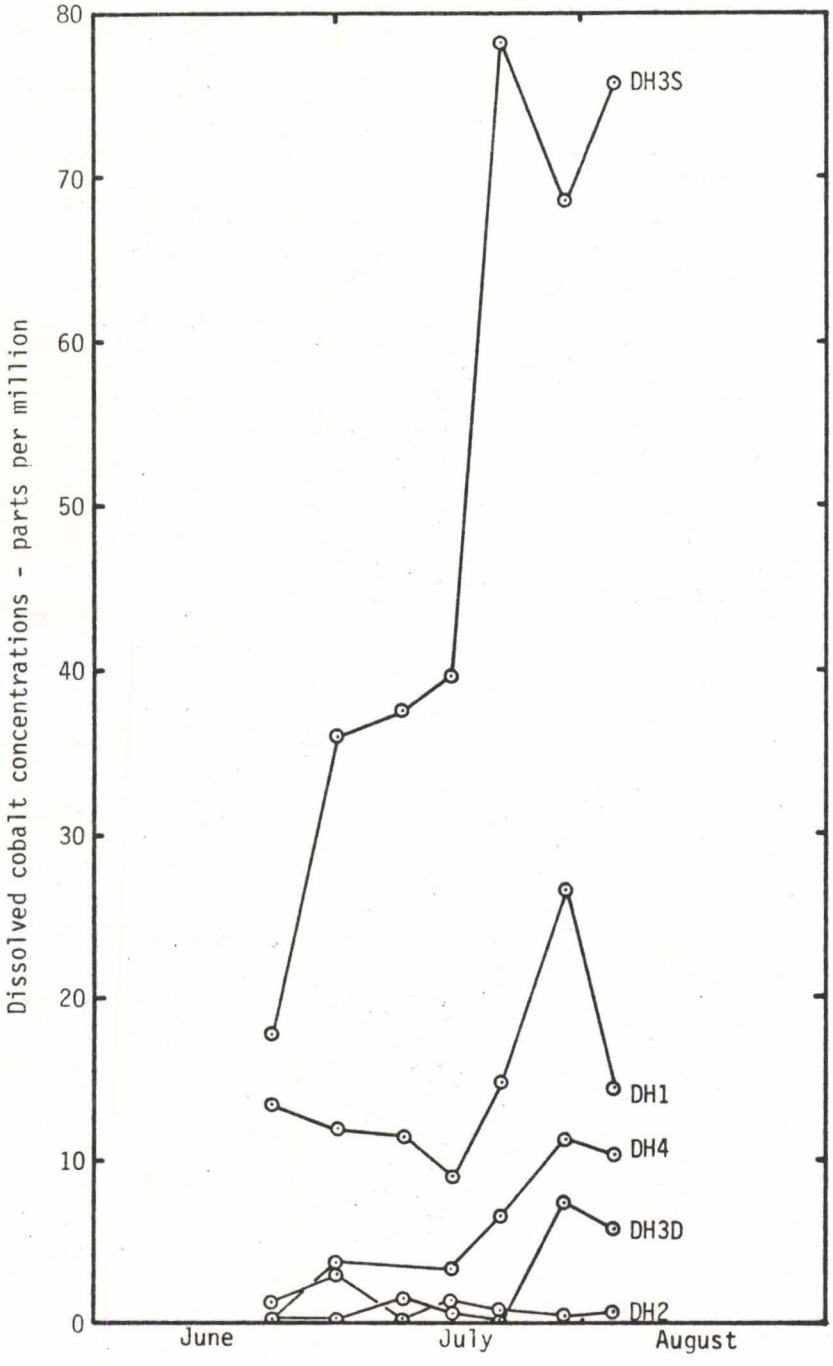


Figure III-17. Dissolved cobalt concentrations for five piezometers in the Blackbird Creek drainage for the 1976 field season.

variations. Increasing metal ion concentrations at DH's 1, 3S, 3D, and 4 during the summer of 1976 are probably caused by decreasing volumes of ground water moving through the respective areas as the low flow period progresses. Snowmelt supplies large volumes of recharge to the ground-water flow systems during the spring runoff period. Smaller volumes of water are available to flush away acid drainage products as ground-water recharge decreases during the low flow summer months, and therefore metal ion concentrations increase. It is believed that the relative differences in metal ion concentrations between drill holes may reflect the relative change in ground-water volumes moving past the station. Therefore, one would expect a smaller increase in metal ion concentrations at DH3D where the volume of ground water flow is fairly constant during the field season. On the other hand, DH3D monitors ground-water quality from a zone where ground water movement may be extremely slow during periods of little or no recharge.

Water-level declines occurred throughout the 1976 field season at DH1 (Figure III-18). These declining water levels indicate that recharge to ground-water flow systems at DH1 decreases during the low flow period. Snowmelt runoff supplies some recharge to flow systems in the valley fill material at DH1 and water level declines would be expected in the absence of continuing recharge during late summer months. Water levels at DH1 may also be influenced by stage changes in the West Fork Blackbird Creek. No information relating stage at station 2 (West Fork Blackbird Creek) and water levels at DH1 is available.

Recharge to the West Fork tailings pile is from melting snow which has accumulated on the tailing surface and runoff inflow from side slopes bordering the tailings pile. The melting snow infiltrates the tailing material rapidly and little ponding is observed during the spring. Drill hole 2

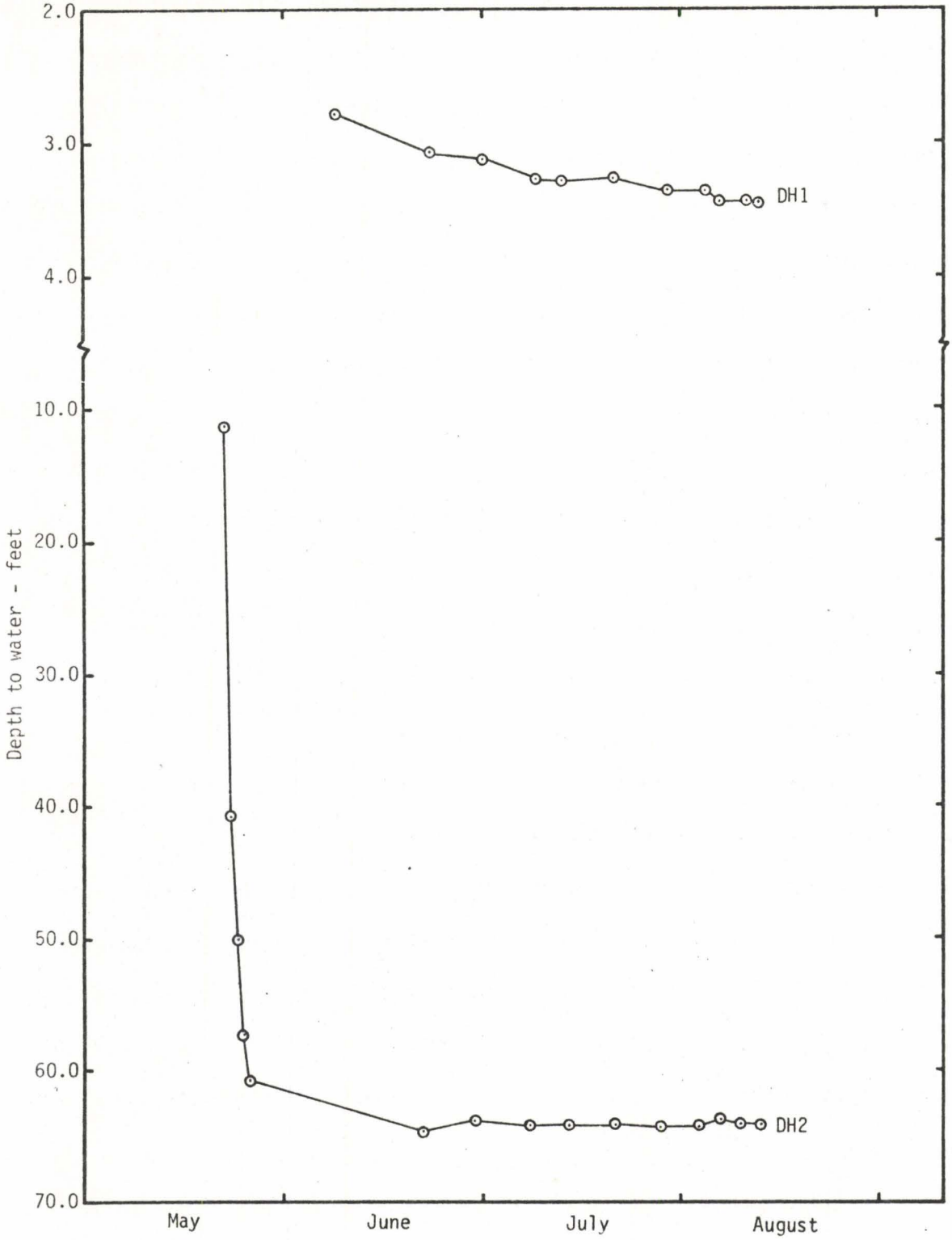


Figure III-18. Water level fluctuations for drill holes 1 and 2, Blackbird Creek, 1976.

(Figure III-18) monitored water levels in the tailings pile during the 1976 field season. Following completion of DH2 on May 27, 1976, water levels in the piezometer dropped rapidly and stabalized at about 64 feet below the tailings surface. At about this same depth, a slime layer was encountered when installing the piezometer. It is believe that the initial water level declines represent the dispersion of a ground-water mound created by the drilling fluid during completion of the hole. The nearly constant water level during the remainder of the summer probably represents a water-slime mixture at the base of the tailings pile.

Variations in Water Quality in Blackbird and Meadow Creeks

Water quality in Meadow Creek and Blackbird Creek is dependent on several parameters including the availability of sulfide minerals, stream discharge, input from sources of point discharge, and location of the sampling station. The relationship between these parameters and water quality is discussed in the following section.

Seasonal Variations of Metal Ions

Total cobalt, copper, and iron concentrations at stations 4 (Blackbird Creek), 6 (Blackbird Creek at mill gate) and 10A (Meadow Creek) for July, 1974, to October, 1975 are shown in Figures III-19, III-20 and III-21. Stream discharge is given for stations 4 and 10A (Figures III-19 and III-21). Variations in metal concentrations follow the same general pattern at each of the three stations. At station 4 (Figure III-19), concentrations increase at the beginning of the spring runoff event. As runoff continues, metal concentrations decrease and lowest values occur during the time of peak discharge. Metal ion concentrations at station 4 increased as discharges decreased during the late summer months of 1975. Total metal ion

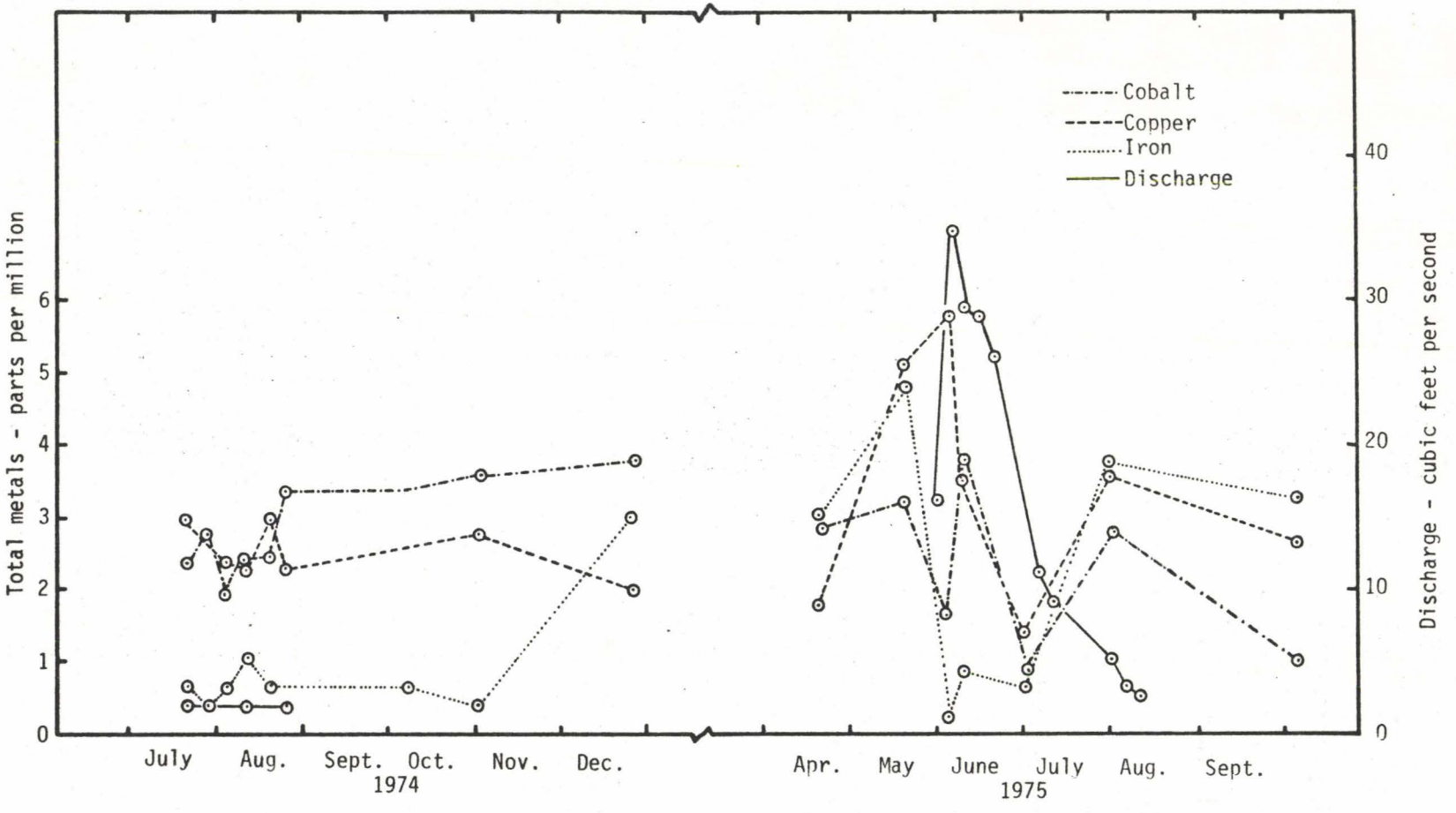


Figure III-19. Total cobalt, copper, and iron concentrations at station 4 (Blackbird Creek) for July to December, 1974, and April to October, 1975.

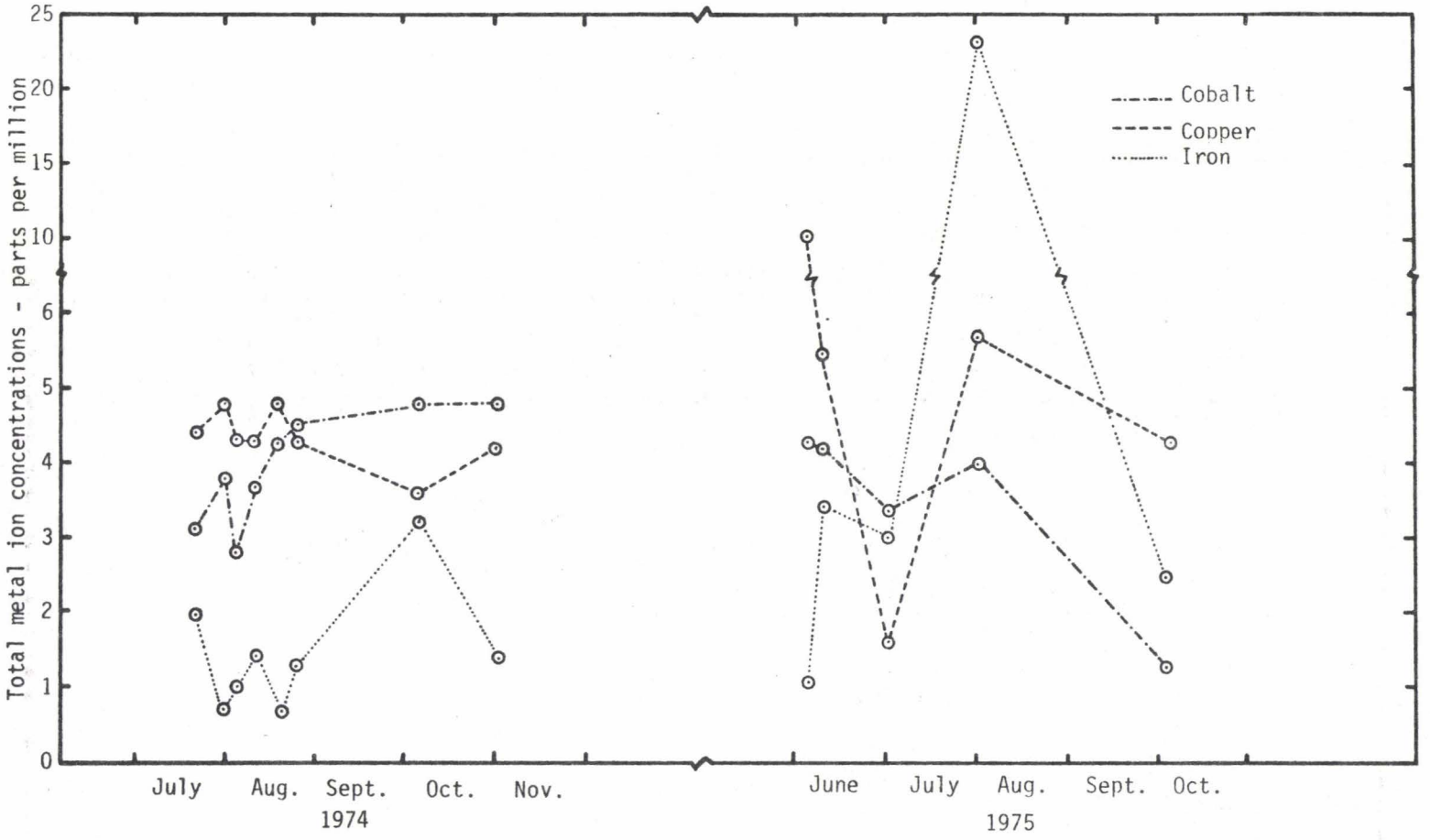


Figure III-20. Total cobalt, copper, and iron concentrations at station 6 (Blackbird Creek) for July to November 1974, and June to October 1975. Discharge data are not available.

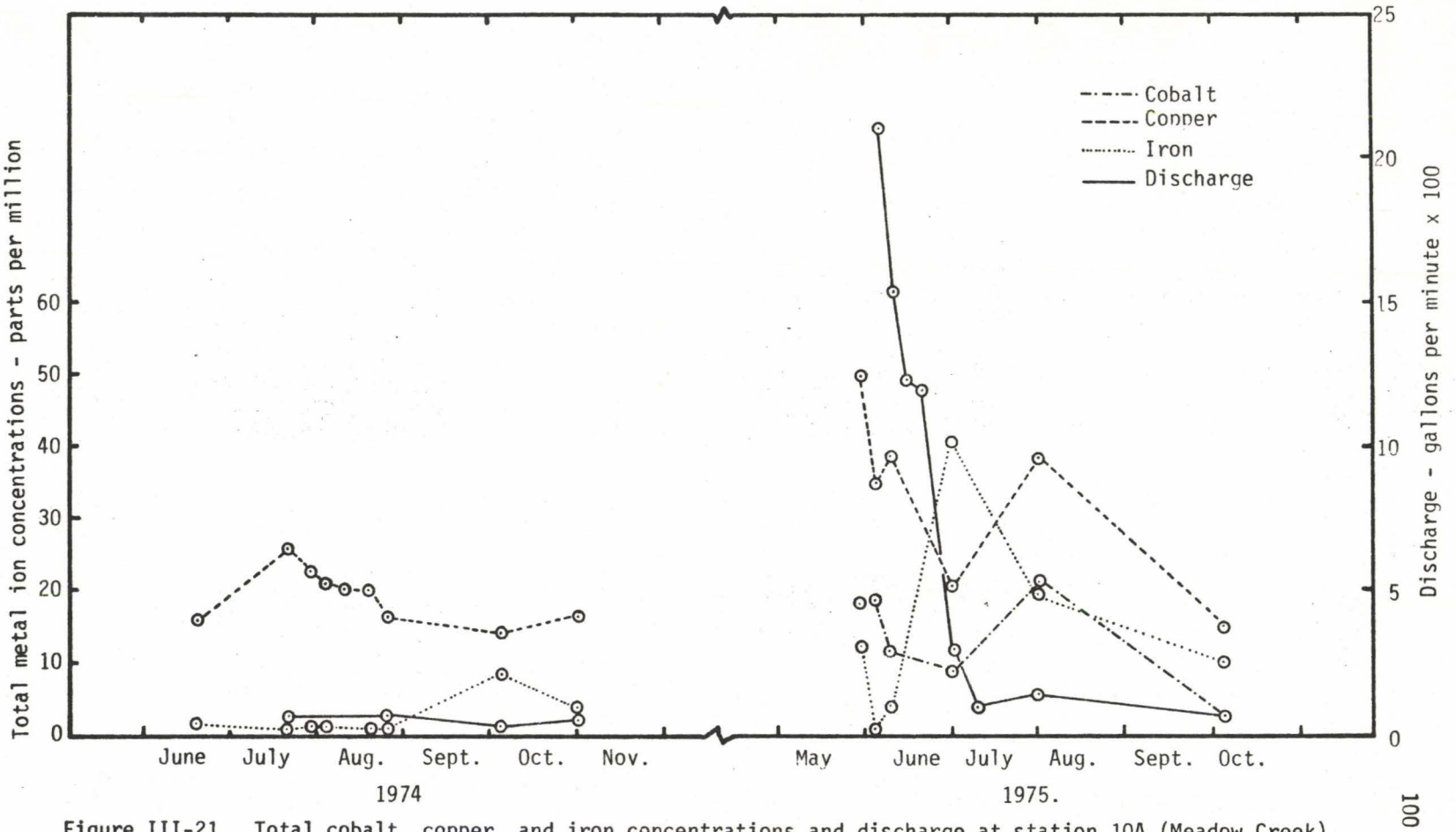


Figure III-21. Total cobalt, copper, and iron concentrations and discharge at station 10A (Meadow Creek) for June to November 1974, and May to October 1975.

concentrations for station 6 (Blackbird Creek at mill) during the period July to October, 1975, are shown on Figure III-20. Discharge data are not available at station 6 for this period but streamflow hydrographs at stations 4 and 6 should closely resemble each other; station 6 would have slightly less discharge as it is upstream of station 4. The data show that in general metal ion concentrations increased during the initial part of the spring runoff event, decreased to the lowest concentrations during the latter part of the runoff event, and increased during the 1975 low flow period. Figures III-19 and III-20 show that a peak in metal ion concentrations occurred August 1, 1975. This sudden concentration increase was the result of a heavy thunderstorm which passed through the mining area the same day samples were collected at the various stations. Surface runoff from the storm flushed oxidation products into the streams. These oxidation products had accummulated since the cessation of spring snowmelt, a period of about 6 weeks. Data for station 10A (Figure III-21) show the same general pattern during the 1974-75 period, with the exception of iron. One high iron value (40:6 ppm on July 1, 1975) may possibly be an analytical error. The peak in metal ion concentrations noted at station 4 and 6 is also seen at station 10A on August 1. Figures III-22 and III-23 show dissolved metal concentrations at stations 4 and 10A for 1976. The variations in dissolved metal ion concentrations are similar to total metal ion variations for the two stations during the 1974-75 field season. High concentrations of metals coincide with the initial spring runoff; concentrations decrease during the middle and late runoff period, and rise during the low flow summer months. Cobalt, copper and iron concentrations were plotted for station 10A for 1969 and stations 6 and 10A for 1971. These plots showed concentration variations similar to those observed for the 1974 through 1976 field season.

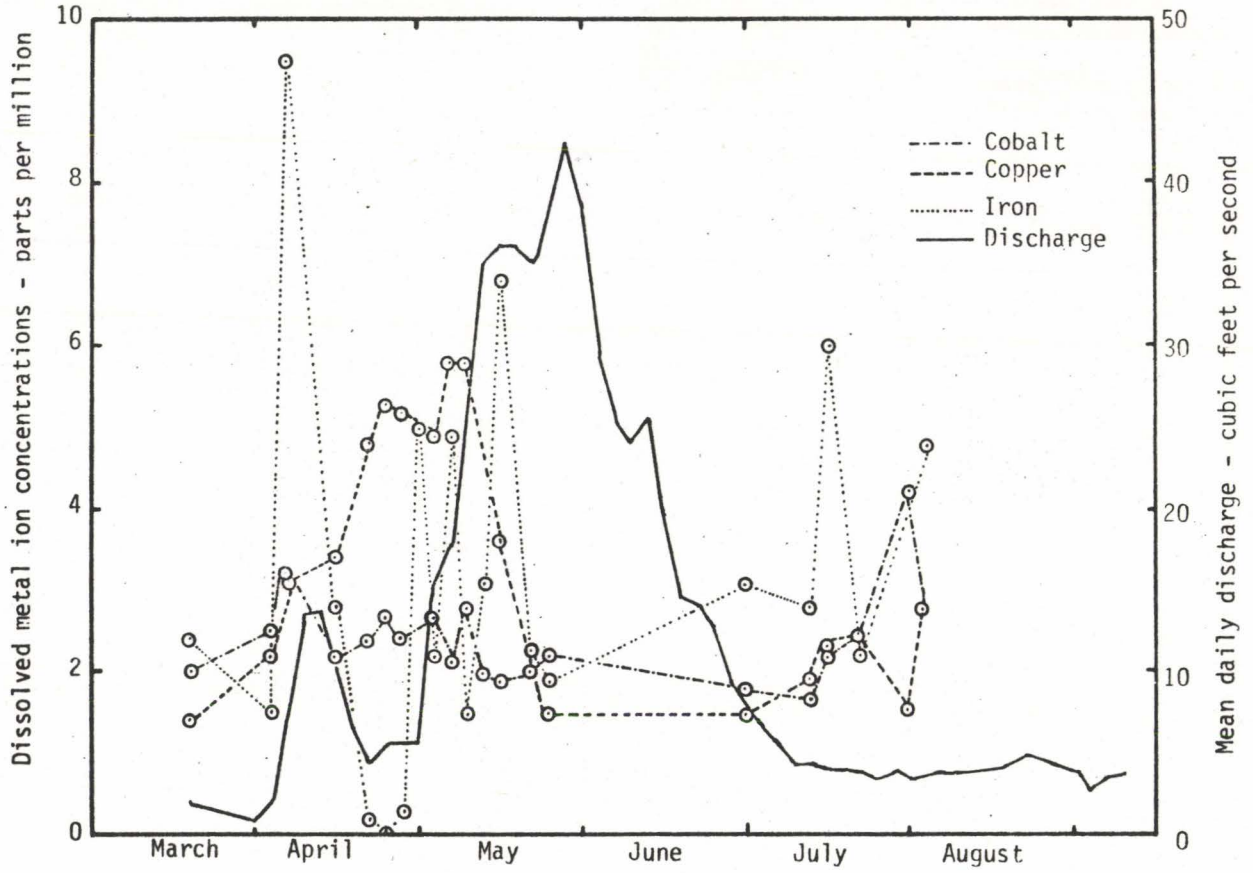


Figure III-22. Dissolved cobalt, copper, and iron concentrations at station 4 (Blackbird Creek) for 1976.

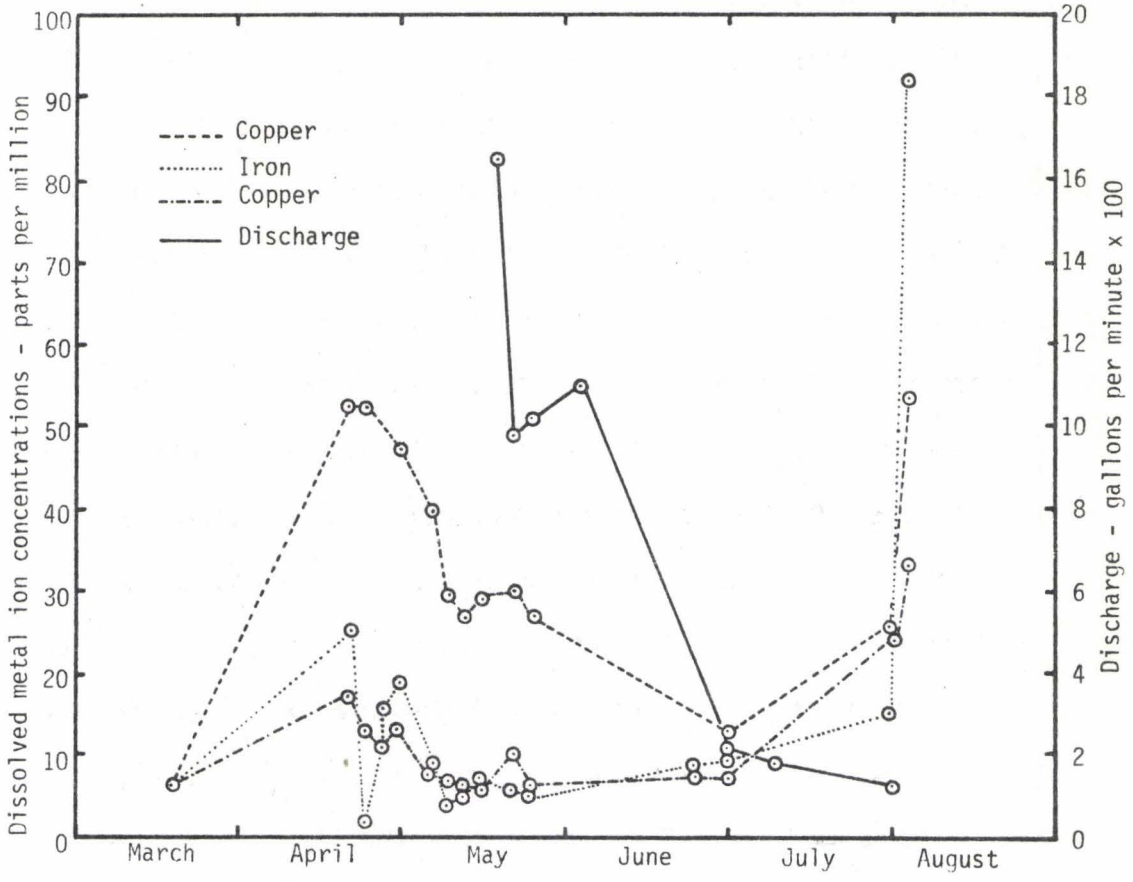


Figure III-23. Dissolved cobalt, copper, and iron concentrations and discharge at station 10A (Meadow Creek) for March to August 1976.

Downstream Variations of Metal Ions

Graphs of metal ion concentrations as a function of downstream position are useful in identifying areas of acid production in the Blackbird Creek drainage. One possible method would be to plot metal ion concentrations vs downstream position for each sampling date but this procedure would require numerous plots. However, from Figures III-19 through III-23, it was seen that similar metal ion concentrations occur at certain times throughout the year, and that these concentrations are also related to stream discharge. A single value representing metal ion concentrations during a particular time period can be obtained by averaging values of all samples collected during that time period. Examination of Figure III-19 (total metal ion concentrations for 1974-75) shows that three such time periods may be recognized, each associated with different metal ion concentrations. These periods are: i) a period characterized by intermediate concentrations of metal ions which occurs during low-flow summer months and extends to the beginning of spring runoff, ii) a period characterized by high metal ion concentrations which coincides with the start of spring runoff when flow is increasing, and iii) a period characterized by low metal ion concentrations which roughly coincides with the high flow and the falling limb of the spring runoff hydrograph. Figure III-22 shows that these same three general divisions exist for dissolved metal ions as well.

Figures III-24 through III-29 show concentration variations as a function of downstream positions for two stations on Blackbird Creek and six stations on Meadow Creek. Sample stations are plotted in downstream order with station 16 at the headwaters of Meadow Creek and station 4 the lowermost monitoring station on Blackbird Creek. Point discharge sources of acid drainage

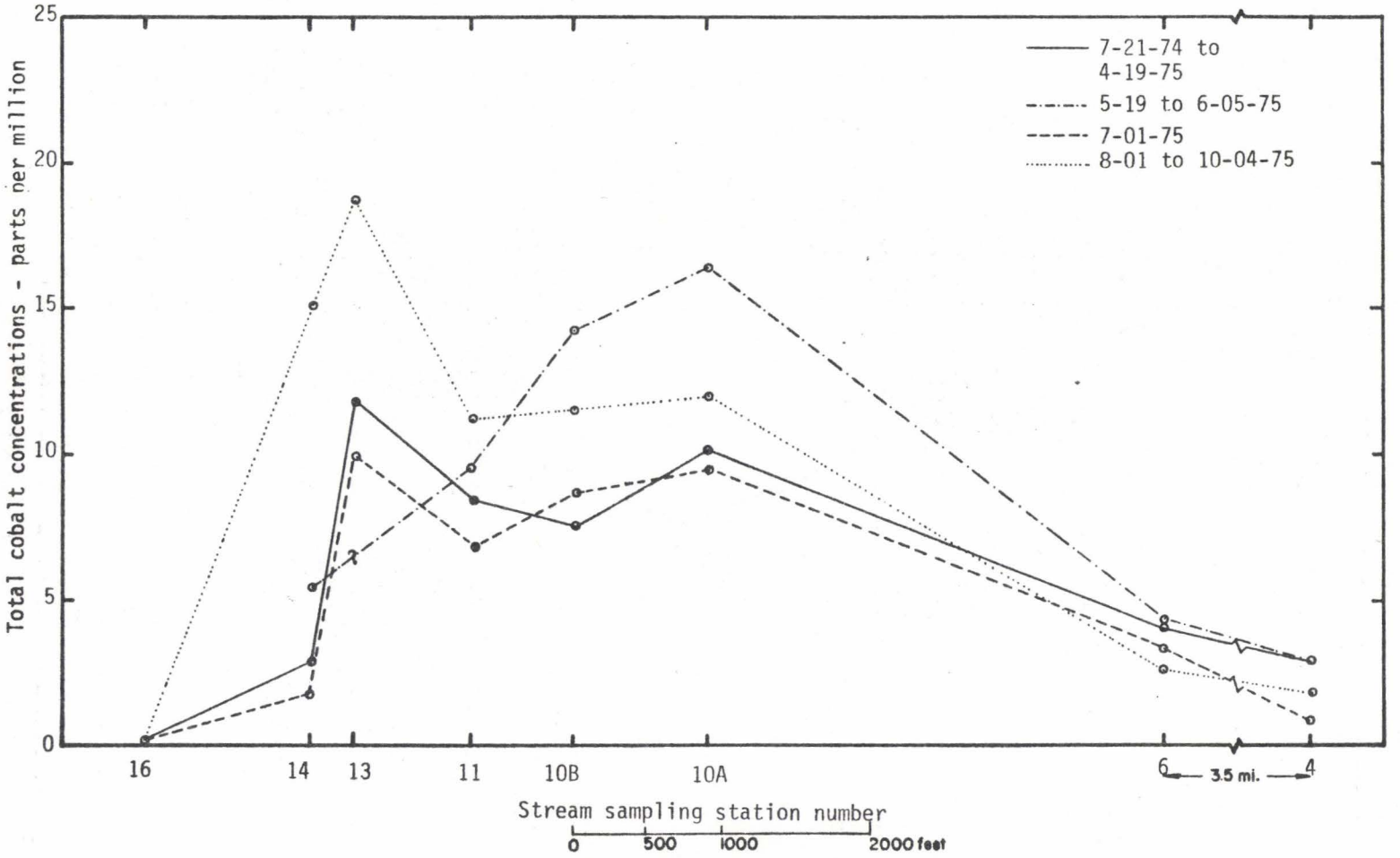


Figure III-24. Total cobalt concnetrations in the Blackbird Creek drainage, July 1974 to October 1975.

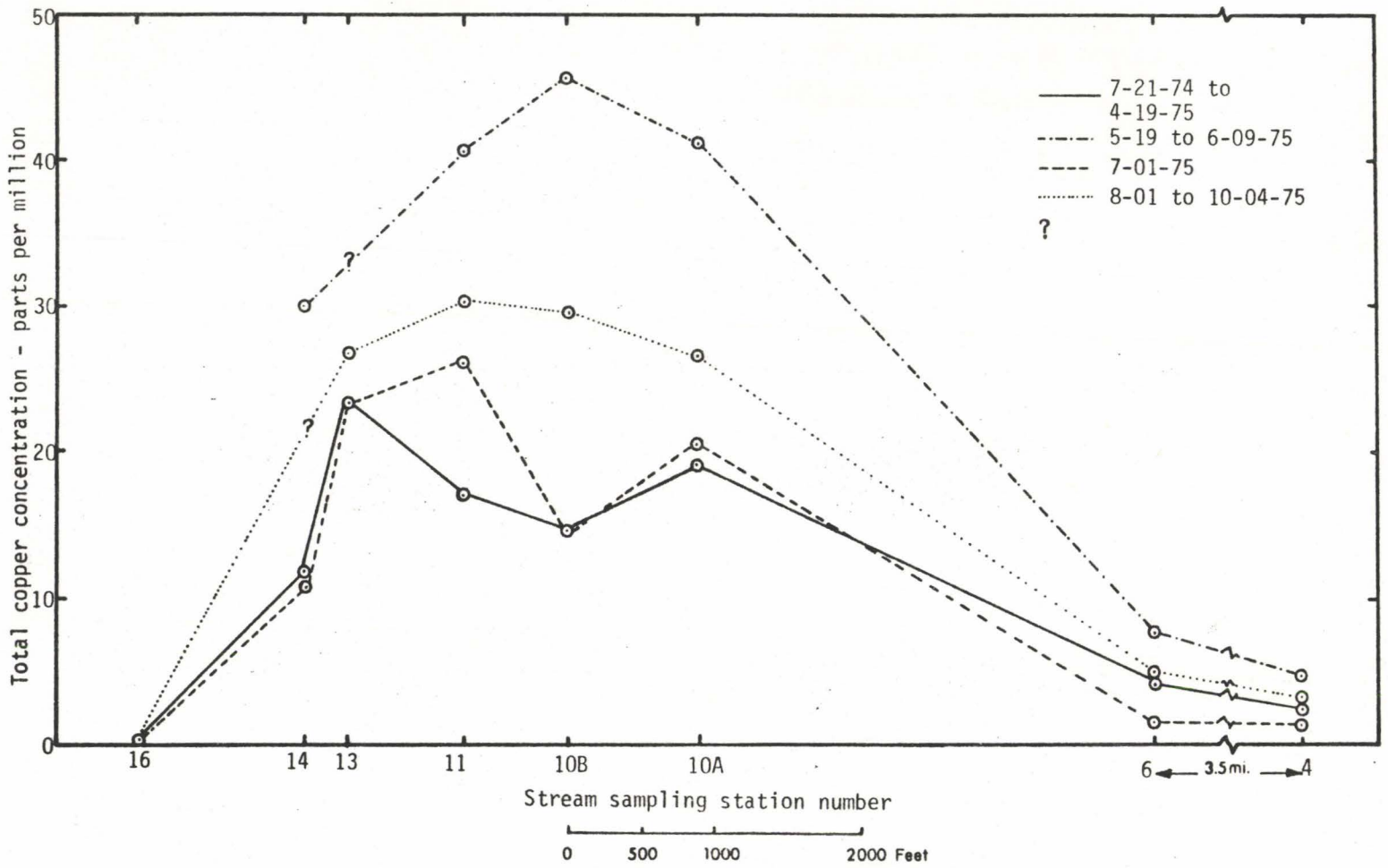


Figure III-25. Total copper concentrations in the Blackbird Creek drainage for July 1974 to October, 1975.

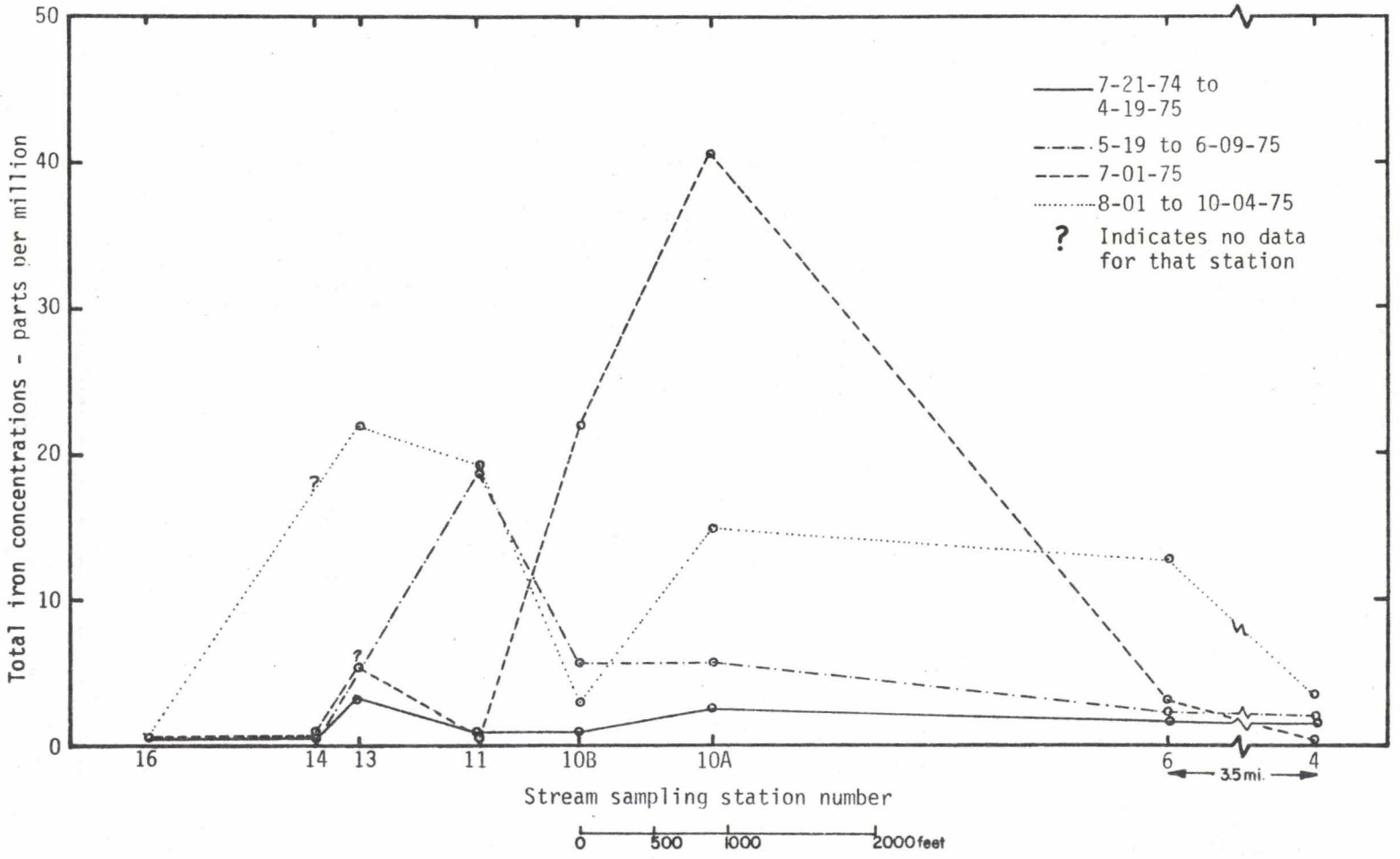


Figure III-26. Total iron concentrations in the Blackbird Creek drainage for July 1974 to October 1975.

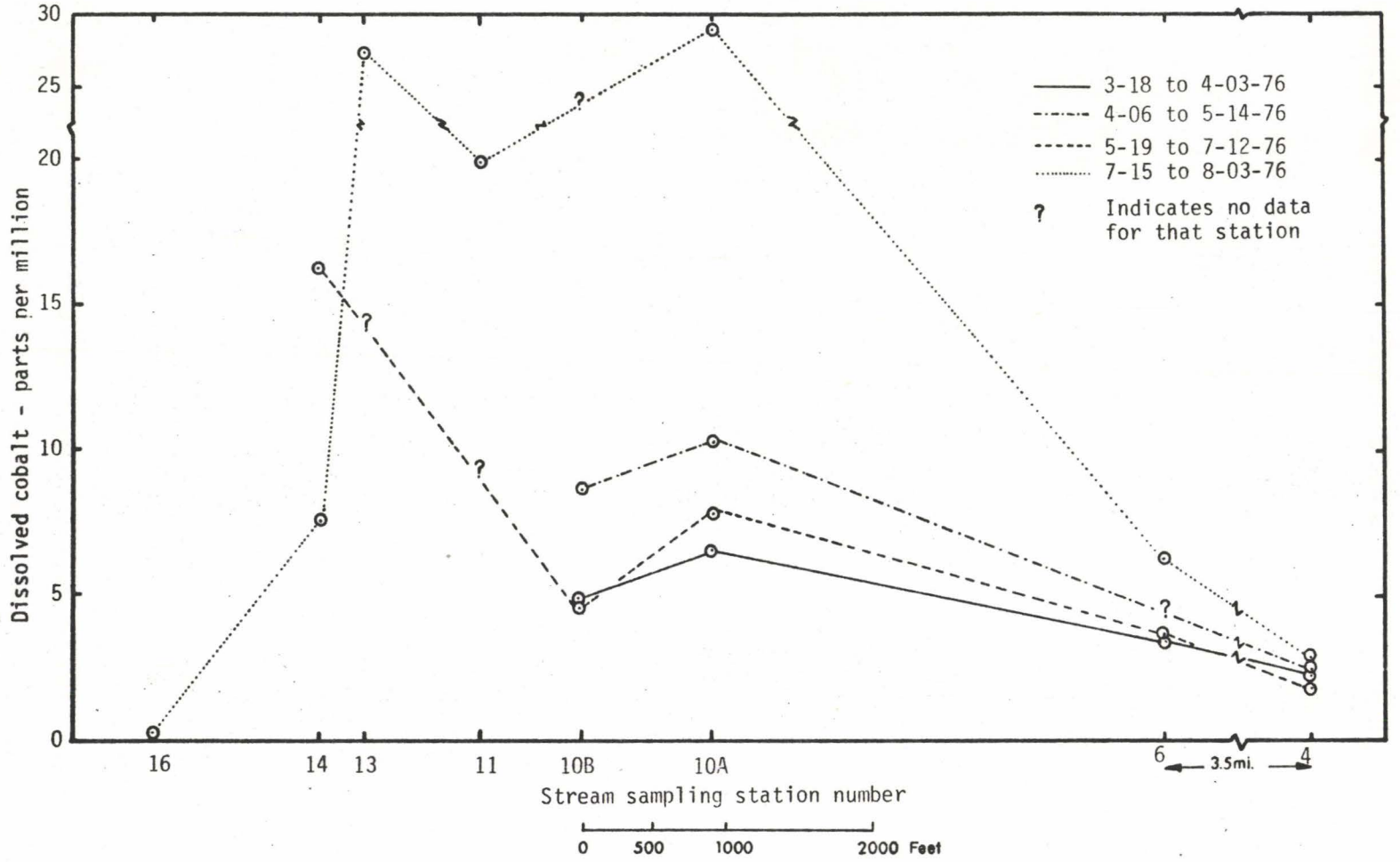


Figure III-27. Dissolved cobalt concentrations in the Blackbird Creek drainage for 1976.

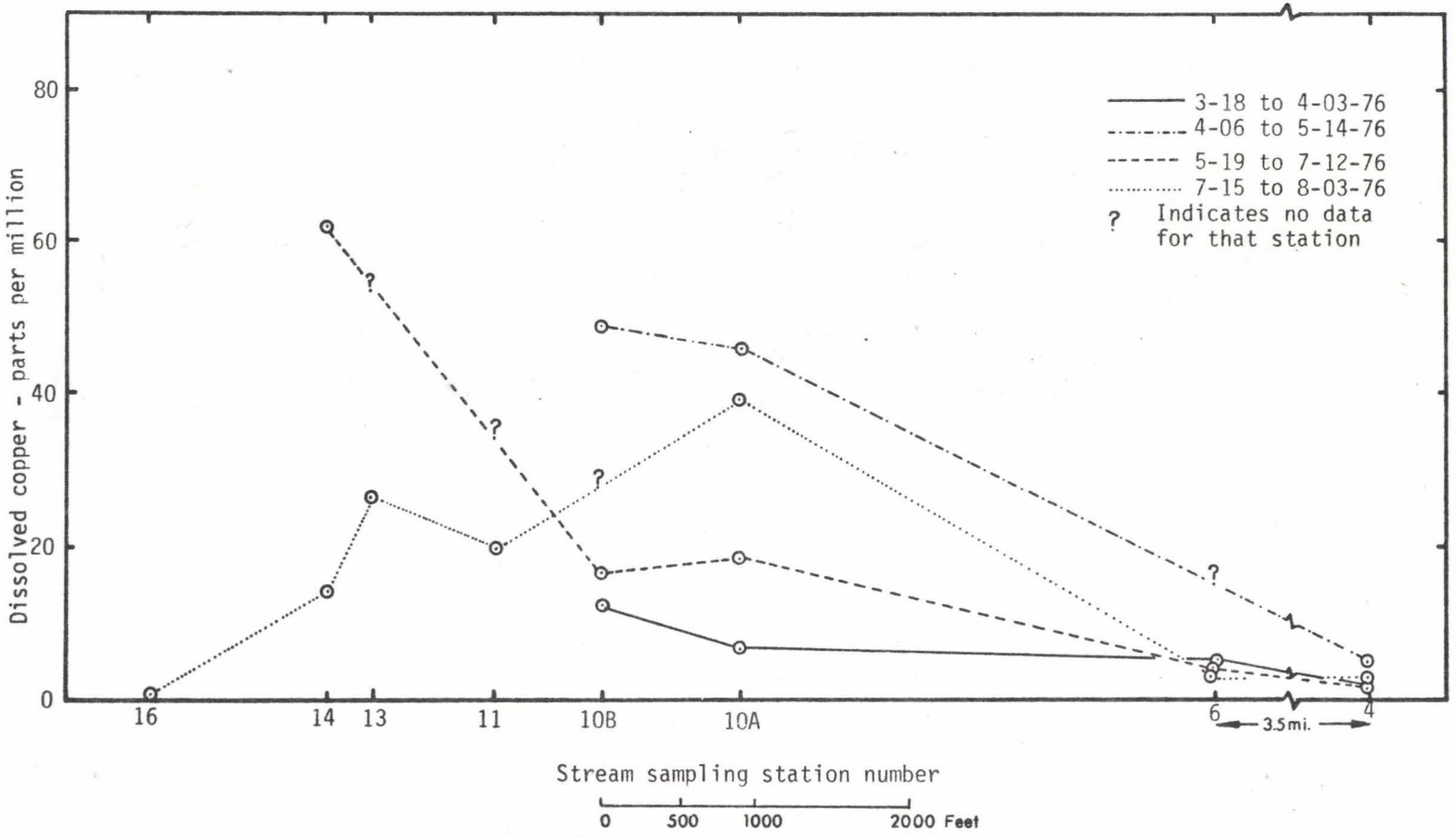


Figure III-28. Dissolved copper concentrations in the Blackbird Creek drainage for March to August, 1976.

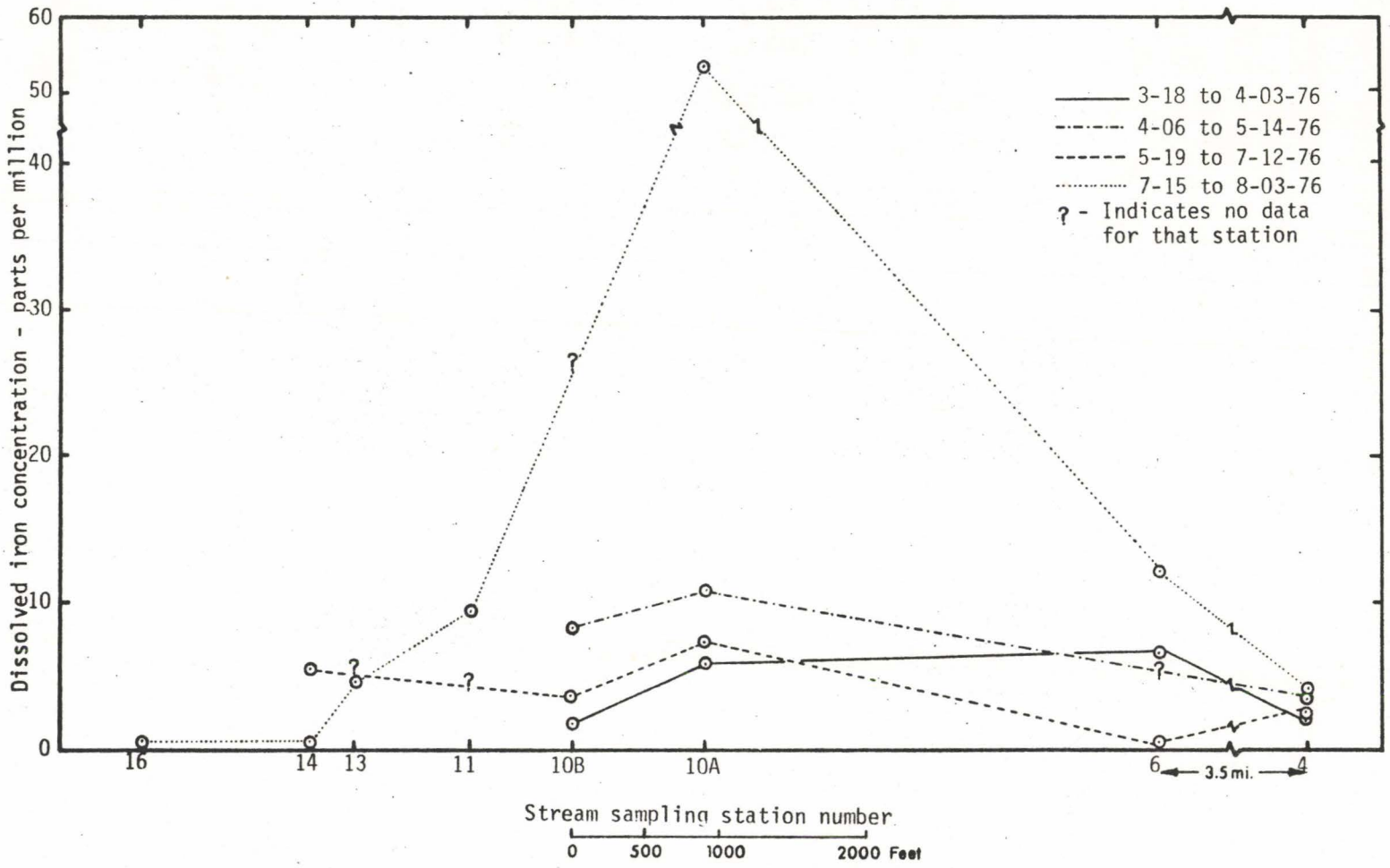


Figure III-29. Dissolved iron concentrations in the Blackbird Creek drainage for March to August 1976.

tributary to Meadow Creek (such as station 10 and 15) are not shown in these graphs. The data for 1974-75 and 1976 were grouped into periods based on variations observed at station 4.

Several conclusions concerning total metal ion concentrations can be noted from Figures III-24 through III-29. In all cases, the highest metal ion concentrations were noted in a 2,700-foot reach of Meadow Creek from station 14 downstream to station 10A. Within this reach, concentration variations occur with downstream position. At the onset of spring runoff (5-19 to 6-05-75), total cobalt and copper concentrations increase from stations 14 to 10A while total iron concentrations reach highest values at station 11 and decrease from this point downstream.

During the latter part of the spring runoff period (7-01-75) copper and cobalt concentrations are less than peak runoff concentrations at all stations and are similar to concentrations observed during the low flow months of 1974 (Figures III-24 and III-25). In addition to the decrease in concentration, variations of cobalt and copper between stations takes a different pattern during the latter part of spring runoff. This pattern is similar to that which occurs during the low flow months of 1974. Iron concentrations show wide variations during the latter part of the spring runoff period of 1975 as well as during other periods of 1974 and 1975. The reasons for these variations were discussed in Chapter II.

Downstream variations for dissolved metals (Figures III-27 through III-29) are similar to downstream variations for total metal ion concentrations. Highest dissolved cobalt, copper, and iron concentrations are found in the same 2,700-foot reach of Meadow Creek. Within this reach of the stream, downstream variations for dissolved metals are similar to downstream variations for total metals. Variations between periods for dissolved metals indicate that only copper has highest concentrations during

the initial part of the spring runoff (Figure III-28). Highest dissolved cobalt and iron concentrations occur during the low flow period of 1976. This is in contrast to data presented in Figures III-19 through III-23 where it was seen that all metal ion concentrations were highest at the beginning of spring runoff. Samples were collected at stations 6 through 16 only once during the 1976 low flow period, on August 3, 1976. The best explanation for high dissolved cobalt and iron concentrations on August 3, 1976 is that runoff from a thunderstrom flushed oxidation products into the streams. Daily precipitation records show that .22 and .05 inches of rain fell at the Cobalt weather station on August 1 and 2 respectively. It is believed that samples collected on August 3rd reflect metal ion transportation by runoff from this storm.

Sample collection during the periods March 18 to April 3 and July 15 to August 3, 1976, corresponds to time of low stream discharge. Examination of Figures III-27 through III-29 shows that concentrations for the late summer low flow period are higher than for the spring low flow period. This is probably due to thunderstorm activity during the late summer months.

Figures III-24 through III-29 show that below station 10A both total and dissolved concentrations of cobalt, copper, and iron decrease to relatively low values. Concentrations are below 10 parts per million (ppm) at stations 6 and 4 for most sampling dates.

The figures also show the influence of the various point sources of poor quality water in the Blackbird Creek drainage. The slight rise in metal ion concentrations between station 14 and 16 is due to a small inflow of poor quality water from the F. S. Waste Pile. Water entering Meadow Creek from the 7400 portal causes a sharp rise in metal ion concentrations between

stations 14 and 13. Concentrations of both total and dissolved metal ions decrease between stations 13 and 11. Good quality water from Spring Creek discharges to Meadow Creek and dilutes the poor quality stream water. Iron precipitates on the stream bottom indicate that some of the metals are also precipitated as insoluble hydroxides. Metal concentrations continue to decrease between station 11 and 10B; but at station 10A concentrations rise sharply due to discharge of acid water in the area of 7100 waste pile. Acid water from Meadow Creek and the 6850 portal is diluted by Blackbird Creek water to produce the water type observed at station 6. Between stations 6 and 4 inflow of good quality ground water and surface water increases the stream discharge and dilutes metal concentrations.

Metal Load Variations with Downstream Position

Metal loads were calculated for sampling stations along Blackbird and Meadow Creeks and the results were plotted as a function of downstream position. Dilution effects caused by mixing of different water types and volumes can be detected in this manner. In addition, comparison of total input and output values can help to locate areas of metal production not previously identified.

Figures III-30 through III-32 show dissolved cobalt, copper, and iron metal loads for 1976. The important fact to note from the figures is that for most cases metal loads increase downstream of station 10A even though large volumes of good quality water enters the stream from upper Blackbird Creek. Plots of the same data for 1971, 1974, and 1975 show that metal loads are higher at station 6 than at station 10A, while 1974 and 1975

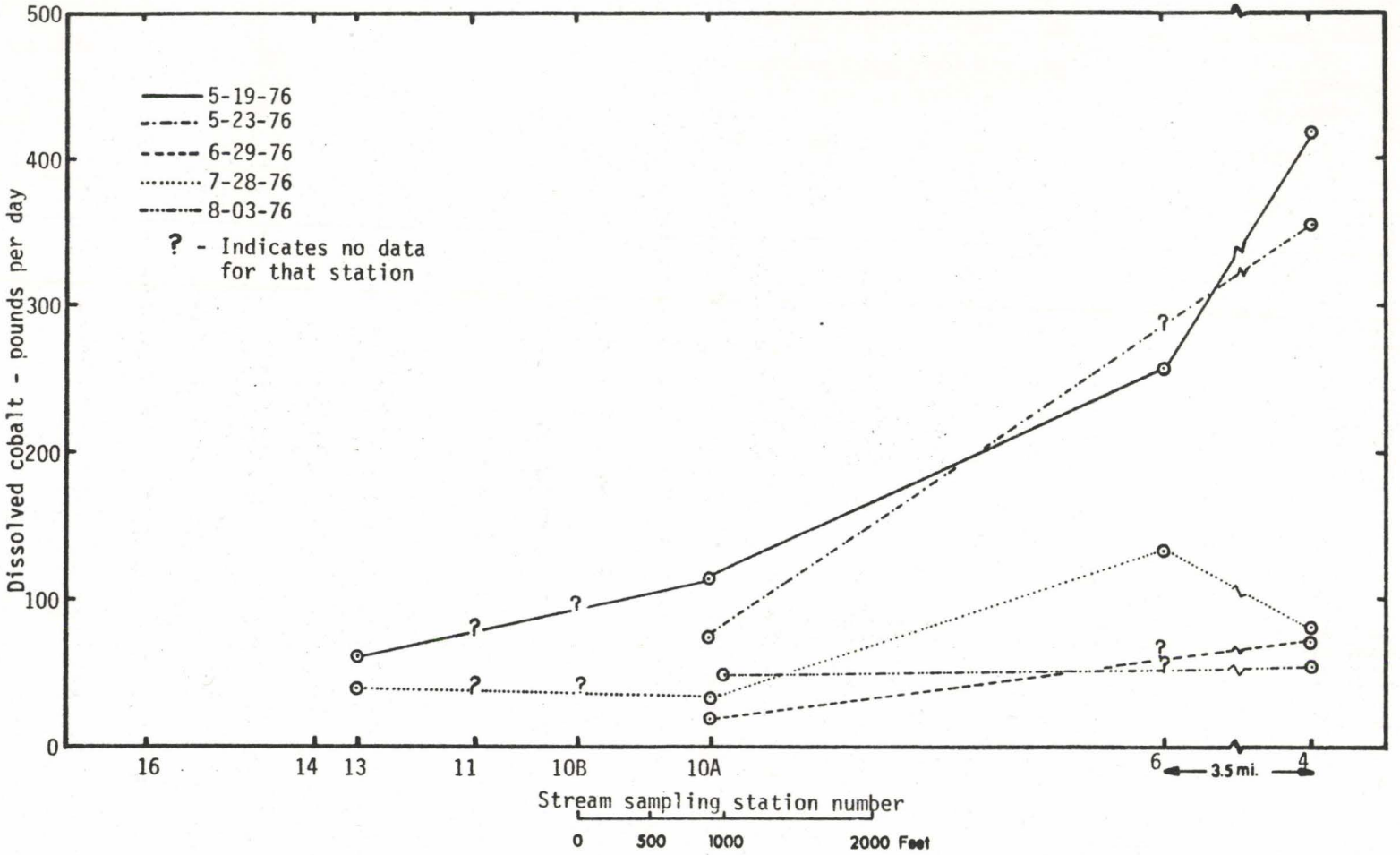


Figure III-30. Downstream variations in dissolved cobalt metal loads along Blackbird Creek for 1976.

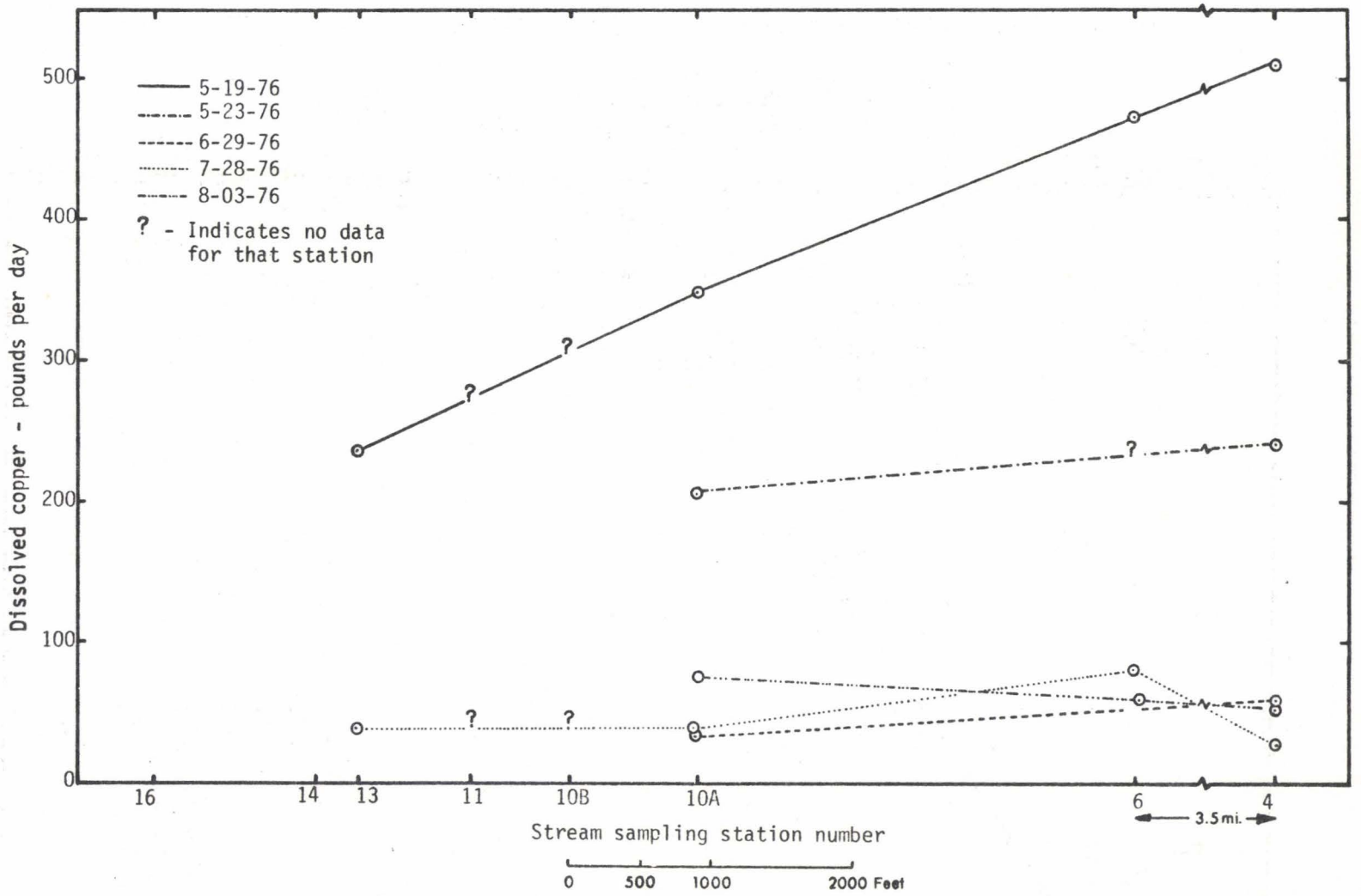


Figure III-31. Downstream variations in dissolved copper metal loads along Blackbird Creek for 1976.

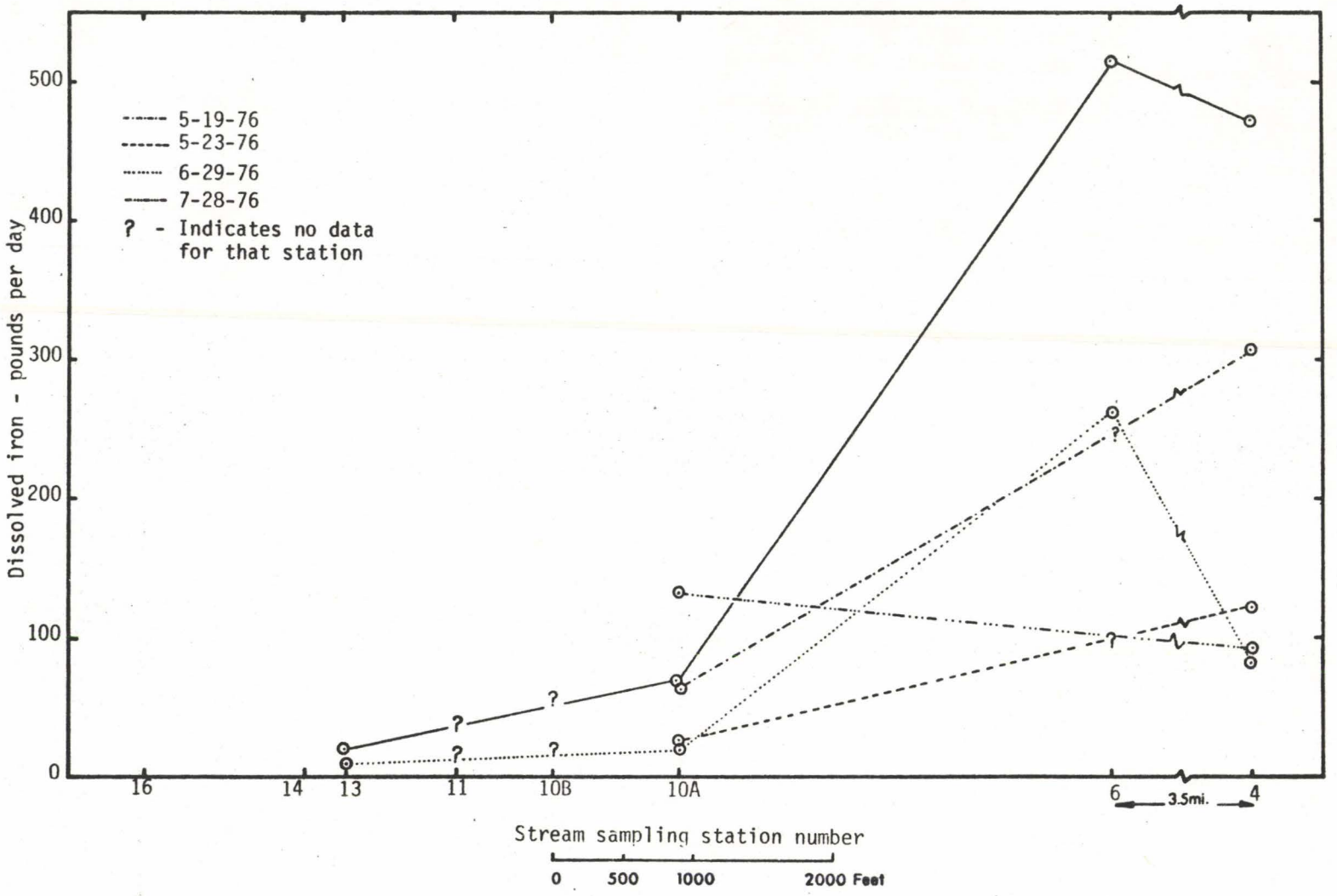


Figure III-32. Downstream variations in dissolved iron metal loads along Blackbird Creek for 1976.

data show that metal loads increase between stations 10A and 4. Metal load contributions in discharge from station 7 (6850 portals) have not been added to metal loads in Meadow Creek in these plots.

The sum of metal loads at stations 7 (6850 portal) and 10A represents total input from known sources of metal production to Blackbird Creek. Figure III-33 shows cobalt, copper and iron metal load balances along Blackbird Creek for 1976. Point M on these figures represents the sum of metal loads in Blackbird Creek from station 7 and 10A. Metal loads calculated from samples at station 6 (Blackbird Creek) should agree with metal loads at point M, but Figure III-33 shows this is not the case. Samples taken May 19 and July 28, 1976, indicate that metal loads are greater at station 6 than at point M. Difference in metal load balances between the two stations are probably due to undetected sources of metal ions and analytical errors.

Between stations 4 and 6, cobalt and copper loads appear to vary with stream discharge while iron loads decrease downstream regardless of discharge. Iron precipitates out as an insoluble hydroxide downstream of station 6 due to pH increase along Blackbird Creek. While pH increases appear to cause some precipitation of cobalt and copper during low flow periods (Figure III-33), increased metal loads during high flow periods are probably due to scouring and reworking of precipitates deposited in Blackbird Creek between station 6 and 4. Although metal ion concentrations are reported as dissolved, the filter size used in the filtration procedure probably permitted the passage of some suspended particles, such as iron precipitates. All tailings were discharged directly to Blackbird Creek before construction of the West Fork tailings pile. While the tailings pile was in use, frequent breaks in the distribution system allowed tailings to flow into Blackbird Creek.

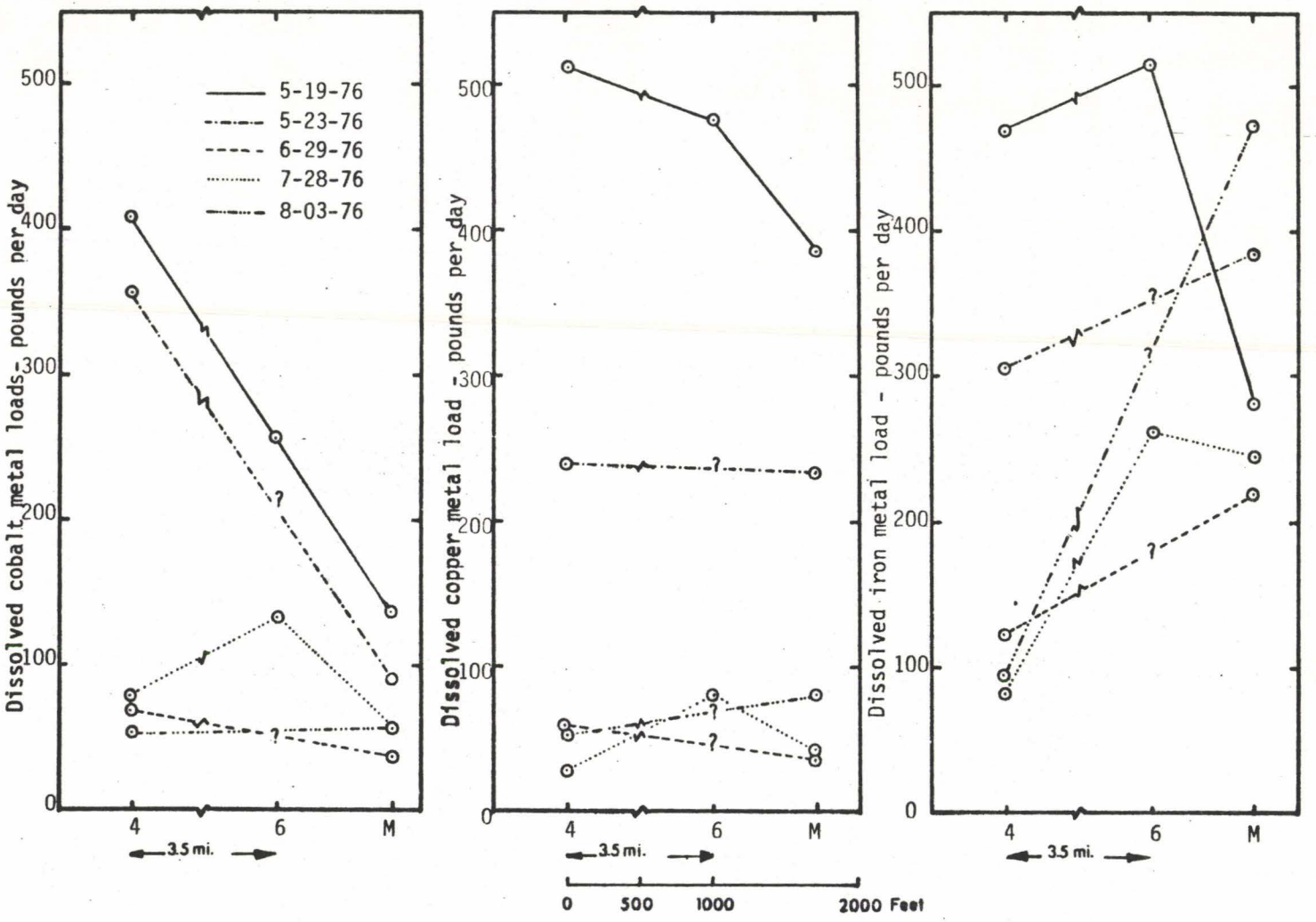


Figure III-33. Dissolved cobalt, copper, and iron metal loads along Blackbird Creek for 1976.

Low pH conditions along the creek can leach cobalt and copper from the accumulation of tailings. Scouring of iron precipitates from the streambed undoubtedly occurs during high flow periods, but decreased iron loads at station 4 indicate that the precipitates do not stay in suspension for long distances.

Metal production from tailings material between stations 4 and 6 may have been accelerated by a stream channel restoration program begun in the fall in 1975. This program was designed to remove tailings and other mining debris from the stream channel by dredging. However, material dredged from the stream channel was piled on the stream bank making it susceptible to leaching and erosion by surface runoff. The dredging program also removed tailings material from what was probably a reducing environment and exposed the material to oxidizing conditions.

Another source of metal contribution to Blackbird Creek may come from the mill area. Ore can be readily found in crusher bins, waste piles, the mill complex, and the mill yard. During high runoff, water from snowmelt flows through most of these areas and can carry oxidation products to Blackbird Creek. Monitoring of possible acid and metal contributions from this source was not attempted due to short flow durations and lack of identifiable discharge points.

Mass Balance Comparisons

Mass balances of cobalt, copper, and iron were computed for the period May 1 through July 31, 1976, for Meadow and Blackbird Creeks. The balances are used to compare total input and output of metal loads during the period and to determine if all sources of metal production have been accounted for. The three month period considered in the computations covers the period of

high metal load production. Mass balance comparisons were done by computing the total metal load input to a stream from all known sources of poor quality water and comparing this with the total metal load output at the lowermost sampling station on that stream. As an example, known sources of metal load input to Meadow Creek include discharge from the St. Joe portal. This total metal load input, computed over a certain time period, was compared with the metal load output at station 10A (Meadow Creek) for the same time period. These mass balance comparisons are only as accurate as the data used in the computations. Discharge data obtained from the stream gaging stations are within five percent of the actual discharge values, and metal ion concentrations are within five percent of the actual metal ion concentrations. An error of 10 percent is therefore possible when using these data to compute mass balances. Small differences in metal loads between inflow and outflow points could not be detected because of these errors. The mass balance comparisons are never-the-less useful in pointing out large metal load imbalances along various reaches of streams in the mining area.

Meadow Creek

Table III-7 shows mass balance comparisons of metal loads for the Meadow Creek drainage during the three month period. The balances show that metal load output at station 10A is about double the calculated input from point sources of acid discharge. Additional metal load input to Meadow Creek occurred from the following non-point discharge sources, listed in order of decreasing importance. (1) ground-water flow from the F. S. Waste Pile past station 17, (2) metals leached from tailings and lowgrade ore between stations 14 and 10A, and (3) ground-water flow from the 7400 waste pile.

Table III-7. Mass balance comparisons for Meadow Creek for the period 5-01 to 7-31, 1976.

	Metal Load (tons)			Discharge (Acre-feet)
	Co	Cu	Fe	
Input				
F. S. Waste Pile (Station 17[a])	0.1	0.3	b	4
7400 Portal (Station 15)	0.6	2.6	0.7	10
7100 Waste Pile (Station 10)	0.4	0.4	1.0	c
St. Joe Portal (Station 9)	0.03	0.06	0.08	c
Total	1.1	3.3	1.7	
Output				
Meadow Creek (Station 10A)	2.3	6.7	2.3	270

[a] 5-19 to 6-21-76. No surface discharge at station 17 after 6-21-76.

[b] Iron concentrations were below detection limits, therefore no iron metal load was reported.

[c] Discharge at these stations is from recharge from Meadow Creek.

Blackbird Creek

Metal load input and output for Blackbird Creek are given in Table III-8. Cobalt and copper output is about 10 percent higher than input from stations 7 and 10A. The sources of this additional metal load were discussed previously. A five percent decrease in iron load is noted at station 4; this decrease is probably not significant due to measurement errors discussed previously. Eighty percent of the total iron load contributed to Blackbird Creek comes from the 6850 portal (station 7), while 87 percent of the total copper load contributed to Blackbird Creek comes from the Meadow Creek drainage. Total metal loads and discharges at station 4 for the 1976 water year are also given in Table III-8.

Summary

Metal production in the Meadow Creek drainage is from the F. S., 7400 and 7100 waste piles, and from the 7400 and 7200 portals and from tailings and lowgrade ore in the Meadow Creek stream channel. Only about one half of the total metal load production can be accounted for by considering point source discharge features; the remaining metal load is from non-point discharge sources including the F. S. Waste Pile, tailings and low-grade ore in the Meadow Creek stream channel and ground-water flow from the 7400 waste pile. Discharge from the F. S. Waste Pile has very low iron concentrations, in contrast to all other acid discharge sources in the Meadow Creek drainage. Low iron concentrations could result from: (1) low iron bacteria populations which are necessary to catalyze the initial ferrous iron oxidation process, or (2) waste rock and ore from the Blacktail Pit having a very low sulfide mineral composition. The latter alternative is probably incorrect since ore from the Blacktail Pit has sulfide mineral composition similar to other ore zones.

Table III-8. Mass balance comparisons for Blackbird Creek for the period 5-01 to 7-31, 1976.

	Metal load (tons)			Discharge (Acre-feet)
	Co	Cu	Fe	
Input				
Station 10A (Meadow Creek)	2.3	6.7	2.3	270
Station 7 (6850 portal)	0.8	1.0	9.5	33
Total	3.1	7.7	11.8	303
Output				
Station 4 (Blackbird Creek)	3.5	8.4	11.2	3,270
	For the 1976 water year:			
Output				
Station 4 (Blackbird Creek)	7.5	13.4	15.2	5,800

Cobalt and copper metal loads at station 4 (Blackbird Creek) are greater than can be accounted for by considering sources of metal input. Additional metal may be leached from tailings in the stream channel, ore and tailings in the mill area, and an ungaged section of lower Meadow Creek.

CHAPTER IV

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

BUCKTAIL CREEK DRAINAGE

Introduction

Bucktail Creek flows north out of the mining area, draining an area of about 1,100 acres (1.7 $mi.^2$) before entering the South Fork of Big Deer Creek. Mining activities have been confined to the headwaters of the drainage basin; stream gaging stations were maintained only on the upper reaches of the stream. Stream gaging on Bucktail Creek was initiated in 1969 by the Idaho Mining Company. University of Idaho personnel monitored stream discharge from 1974 to 1976.

Stations 19, 20, 22 and B1A monitor input of acid discharge to upper Bucktail Creek while station 23 reflects total water quality and quantity output from the 325 acre (0.51 $mi.^2$) drainage area above this site. Stations 21 and B1 through B7 are intermediate stations established to monitor water quality and quantity variations between stations 19 and 23. Surface runoff and ground water entering Bucktail Creek below station 23 is generally unaffected by mining and is assumed to be good quality. Table IV-1 lists gaging stations in the upper Bucktail Creek drainage with periods for which data are available. Figures IV-1 and IV-2 show locations of sampling stations in the Bucktail Creek drainage. Discharge measurements were made at approximately weekly intervals for stations listed in Table IV-1; no continuous stage recorders were maintained at Bucktail Creek sampling stations. Discharge was not monitored for sampling stations downstream of station 23.

Table IV-1. Discharge stations in Bucktail Creek drainage with periods for which discharge data are available.

Station	Description	Period of Record			
		1969	1974	1975	1976
19	Headwaters	----	7-21 to 11-02	6-13 to 8-08	5-24 to 8-03
20	7265 portal	2-24 to 10-01	7-21 to 11-02	6-13 to 8-08	----
21	below 7265 waste pile	----	7-21 to 8-25	6-18 to 8-14	5-24 to 8-03
22	7117 portal	4-07 to 10-01	7-21 to 11-02	6-13 to 8-14	----
B1	below 7117 portal	----	----	7-26 to 8-14	7-01 to 8-03
B1A	above seep zone 1	----	----	8-14 only	7-01 to 8-03
B2	below seep zone 1	----	----	7-26 to 8-14	7-01 to 8-03
B3	below seep zone 2	----	----	7-26 to 8-14	7-01 to 8-03
B4	below seep zone 3	----	----	7-26 to 8-14	7-01 to 8-03
B5	above West Fork	----	----	7-26 to 8-14	7-01 to 8-03
B6	West Fork	----	----	8-01 only	----
B7	below West Fork	----	----	7-26 to 8-14	7-01 to 8-03
23	at culvert	4-25 to 10-01	7-21 to 11-02	6-13 to 8-14	5-25 to 8-03

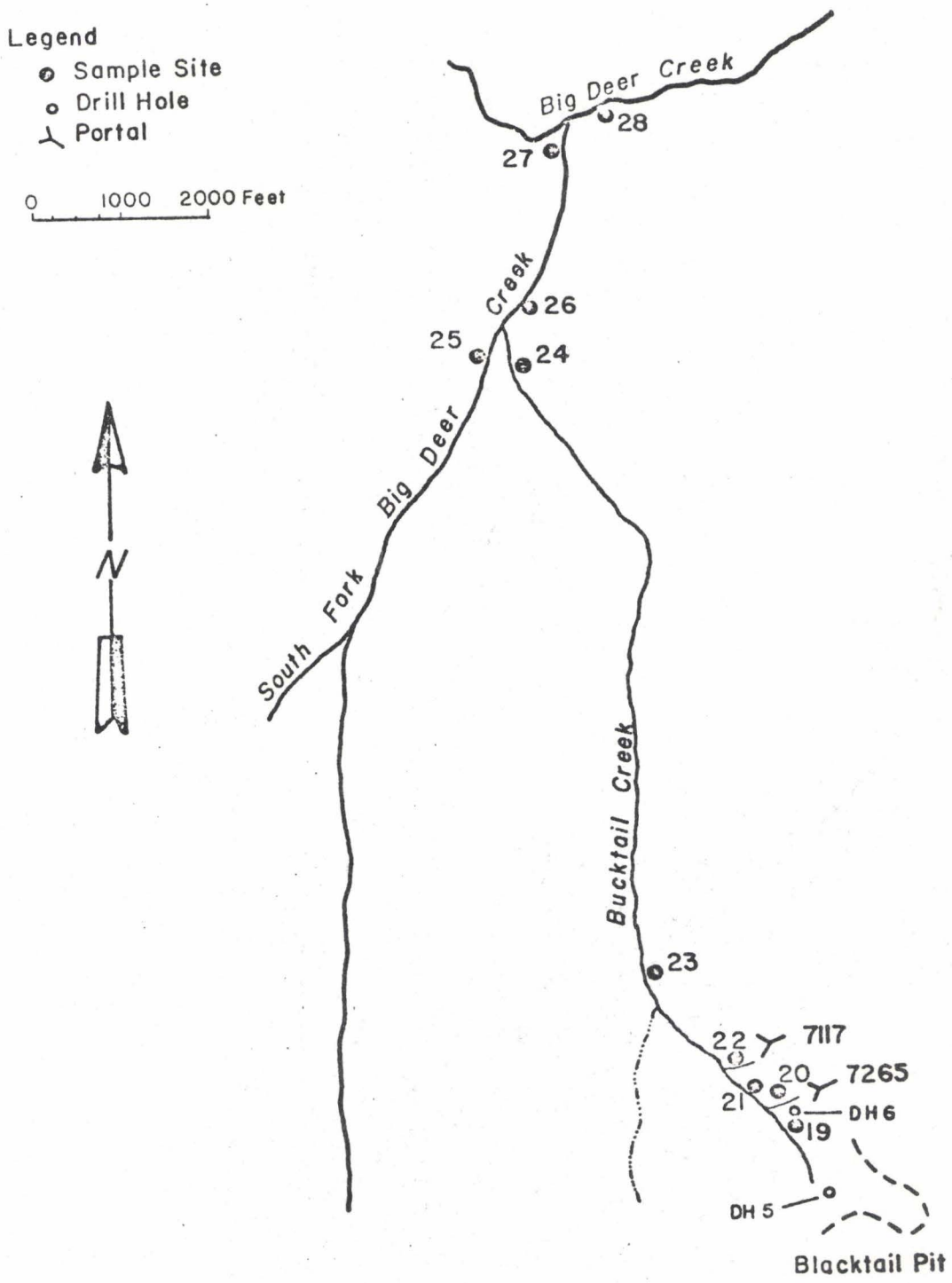


Figure IV-1. Location of sampling stations on Bucktail Creek. Stations B1 through B7 are shown on Figure IV-2.

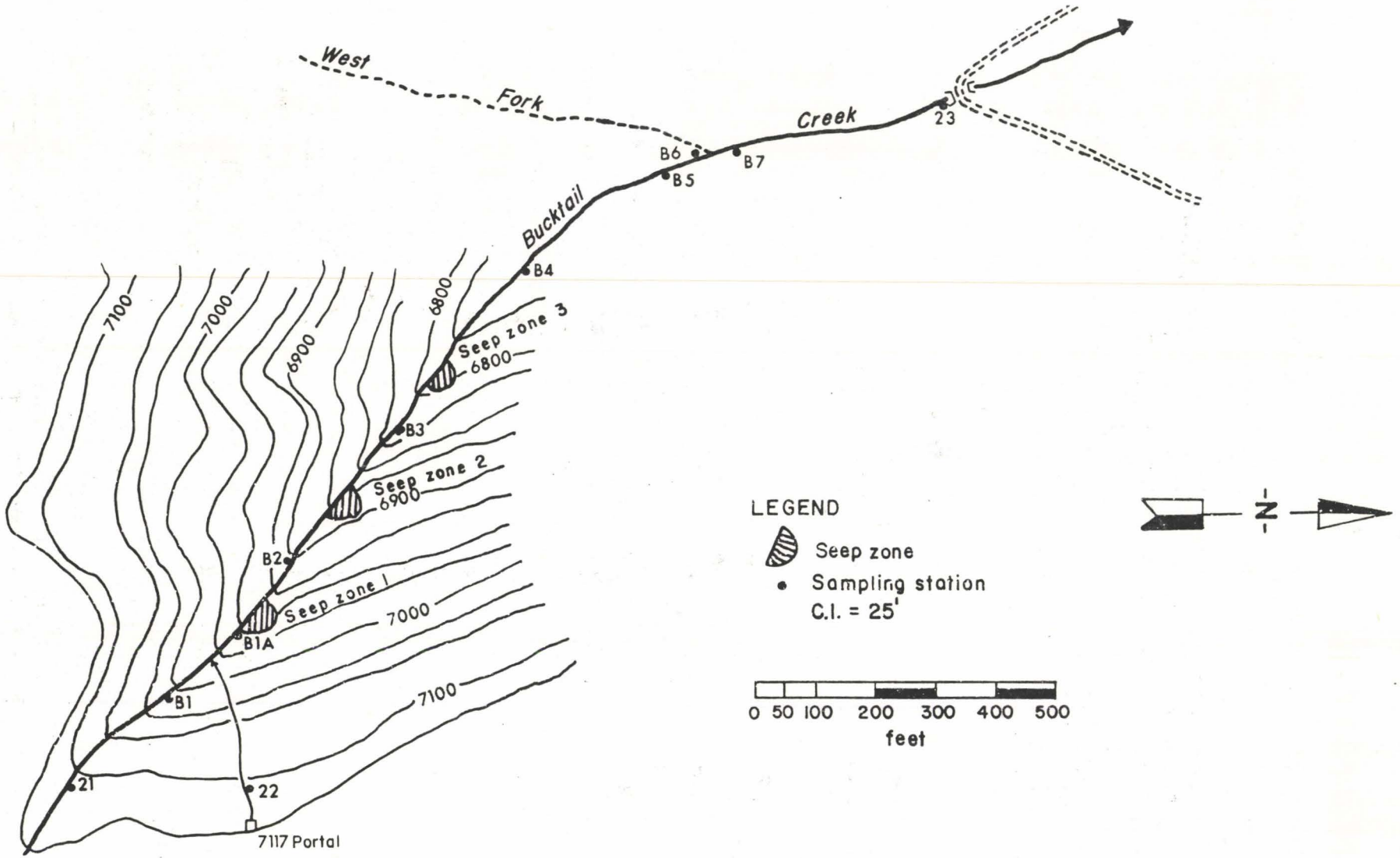


Figure IV-2. Location of sampling stations B1 through B7, Bucktail Creek.

Sources of Acid Contribution in the Bucktail Creek Drainage

Contributions of acid mine drainage to Bucktail Creek can be grouped into discharge from surface water features such as the 7117 and the Blacktail Pit waste piles, and discharge from mine workings such as the 7265 and 7117 portals. Water quality and quantity changes observed at the various stations helped to identify sources and amounts of acid contributed to Bucktail Creek. In addition, two piezometers were installed in waste piles in the Bucktail Creek drainage to provide information on water quality and ground-water levels within the waste piles.

Surface Waste Features

Blacktail Pit Waste Piles

The Blacktail Pit waste piles consist of a series of benches of waste rock and low grade ore piled at the head of the Bucktail Creek valley. The total volume of this waste material is approximately one million cubic yards. The waste material directly north of the Blacktail Pit burys the upper section of the stream channel for a distance of about 500 feet. For the purpose of the following discussion, this segment of the waste pile will be referred to as the Blacktail Pit waste pile. Ground-water discharge from the base of this waste material forms the headwaters to Bucktail Creek. Thick strands of vegetation seen in pre-mining air photos suggest that this was a ground-water discharge area prior to placement of the waste material.

Present discharge from the headwaters of the creek is monitored at station 19 (Figure IV-1). Discharge at this station ranges from about 100 gpm during spring runoff to no discharge during late winter months when freezing

conditions occur. Table IV-2 shows average discharge and water-quality parameters at station 19 during the 1974 low flow period. These averages were computed from seven discharge and water-quality observations made during the period July 21 to November 2, 1974. Ground water discharging from the base of the Blacktail Pit waste pile is the source of streamflow during the low flow period. This ground-water discharge represents the gradual release of water stored in the waste pile material from spring snowmelt.

Water quality at station 19 is characterized by high cobalt and copper concentrations, low iron concentrations, and moderately low pH values (Table IV-2). The pale-blue color of samples collected at station 19 reflects the high copper ion concentrations in the water. The moderately low pH conditions (average pH 3.9) apparently restrict iron concentrations. Figures IV-3 and IV-4 show the distribution of the Fe^{+2} and Fe^{+3} as a function of pH. Figure IV-4 shows that above a pH of 3.0, Fe^{+3} exists as the insoluble hydroxide $Fe(OH)_3$. Therefore, acid mine water with a pH of 3.0 or higher should contain little or no Fe^{+3} ions in solution. Figure IV-3 shows that Fe^{+2} ions will remain in solution up to a pH of 8.0. However, it is believed that Fe^{+2} ions are rapidly oxidized to the Fe^{+3} state where precipitation as iron hydroxide ($Fe(OH)_3$) takes place. Thus it is believed that low iron concentrations at station 19 are due to moderate pH values which cause Fe^{+3} ions to precipitate out of solution. Cobalt and copper are easily brought into solution, as shown by two samples collected during the 1975 spring runoff period (Table IV-3). Sample 109 was collected from a rill flowing about 20 gpm 50 feet downslope from a melting snowbank; sample 110 was taken from the same rill about 150 feet downslope from the snowbank. The increase in cobalt and copper concentrations over a distance of only 100 feet shows

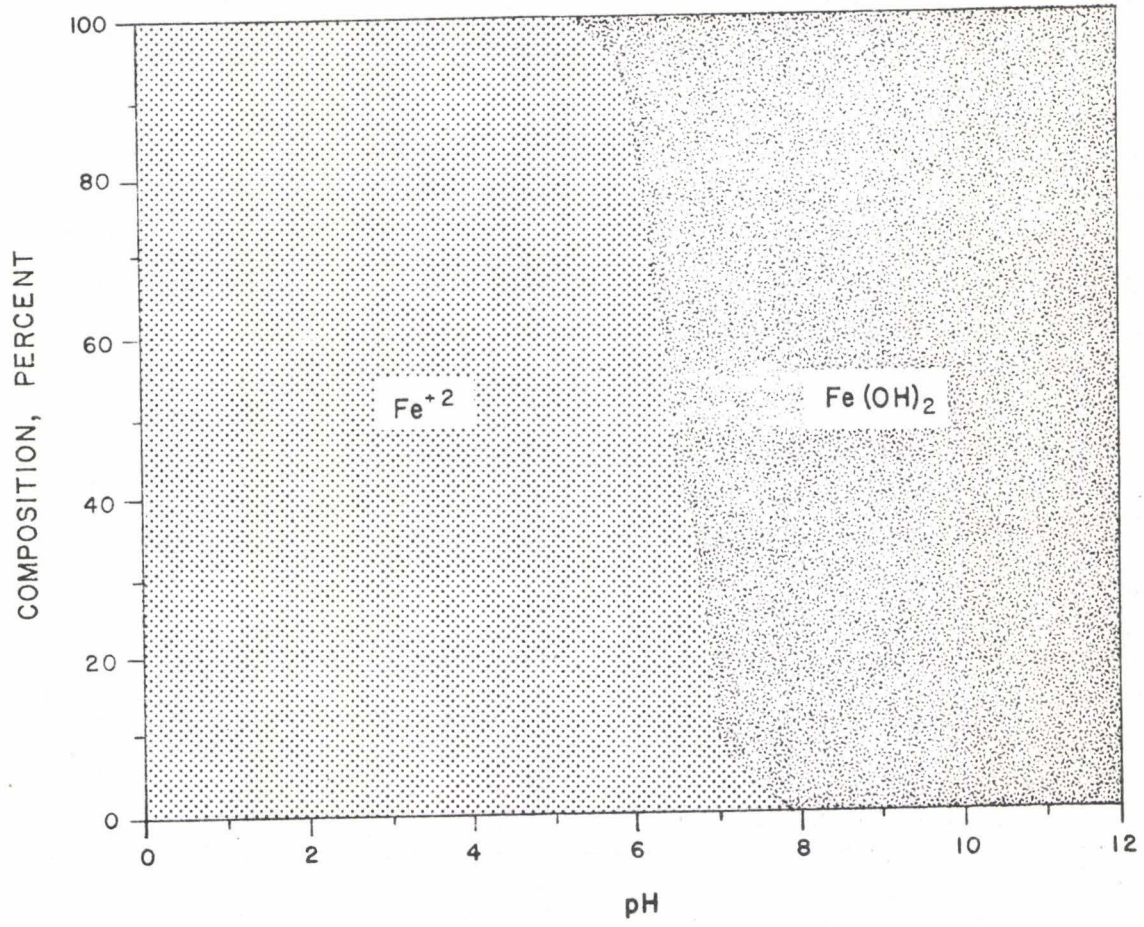


Figure IV-3. Distribution of Fe^{+2} and $Fe(OH)_2$ as a function of pH.

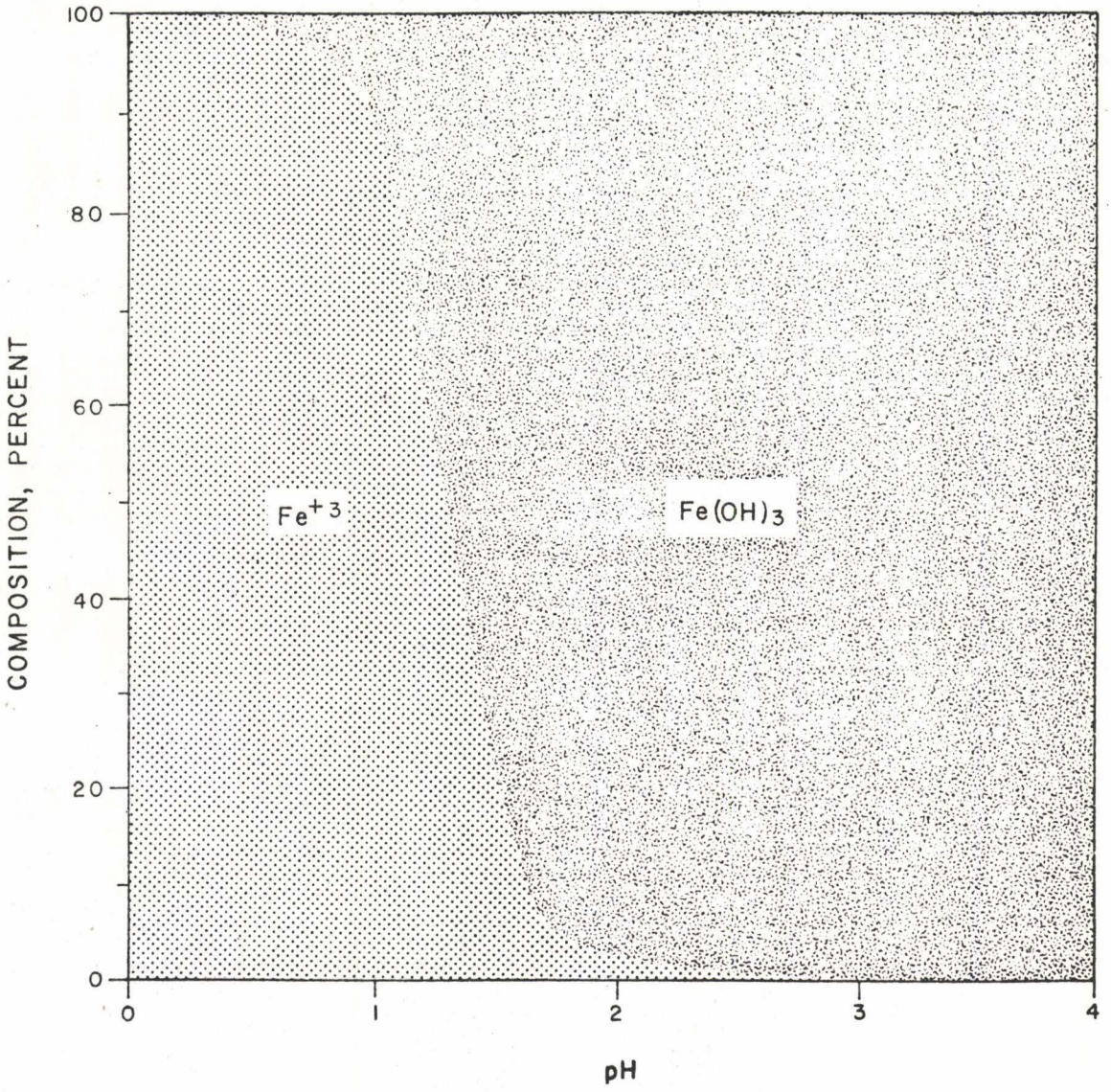


Figure IV-4. Distribution of Fe^{+3} and $Fe(OH)_3$ as a function of pH.

Table IV-2. Water quality and quantity at selected stations on Bucktail Creek for the 1974 low flow period. Averages are calculated from seven observations.

Station	Period	Average Discharge (gpm)	Average Total Metal Ion Concentrations (ppm)			pH
			Co	Cu	Fe	
19	7-21 to 11-02	3.7	212	1680	0.3	3.9
20 (7265 Portal)	7-21 to 11-02	4.1	73.1	94.6	59.9	2.9
21	7-21 to 8-25	7.7	136	1030	1.2	3.7
22 (7117 Portal)	7-21 to 11-02	3.9	17.9	13.5	5.7	3.2
23	7-21 to 11-02	29.7	65	400	0.3	3.6

how effective the leaching process can be. This melt water was observed infiltrating the waste pile a short distance downslope. Continued leaching probably occurs as this water moves down through the waste material.

Table IV-3. Water quality of surface runoff in Blacktail Pit waste pile during spring, 1975. (Metals are total ions, in parts per million.)

Sample No.	pH	E.C.	Co	Cu	Fe	Mn	Mg	Ca
109	4.9	100	1.9	4.9	1.5	0.8	9.6	7.7
110	4.6	190	5.0	20.6	1.8	0.8	8.2	10.0

The ore material in the Blacktail Zone in and around the Blacktail Pit is an additional source of sulfide minerals available for leaching. The Blacktail Zone is a highly fractured zone where ore minerals have been emplaced. The Blacktail Pit and associated underground workings have been developed in the Blacktail Zone and large blocks of ore remain in this zone. The pit has a drainage area of 25 acres; this area includes the pit itself and surrounding area which drains towards the pit. Snow accumulation in the pit area is reduced by high wind velocities on the ridge separating the Bucktail and Meadow Creek drainages. Snowdrifts tend to accumulate on the Meadow Creek side of the drainage divide.

Water which does enter the Blacktail Pit is funneled down partially blocked raises in the bottom of the pit to the 7,265 level. Personnel of the Idaho Mining Company indicated that surface runoff ponded in the pit for the first two or three years after mining operations stopped. Ponding ceased when sand filled workings beneath the pit collapsed; surface runoff can now discharge directly to the subsurface workings. Field observations made on the 7400 level during the 1975 field season showed that a water-lime

mixture injected into the pit flowed down to the 7400 level and from there down the 896 R to 7265 level (Figure IV-5). Therefore, any metal ions leached from ores immediately around the Blacktail Pit would most likely enter Bucktail Creek from the 7265 portal, downstream of station 19.

Water quality at station 19 shows certain similarities to water samples collected at station 17 (F. S. Waste Pile, Blackbird Creek drainage) during the same five month period for 1974 (Table IV-4). Values of pH at the two stations were identical and iron concentrations were very similar. Both the F. S. and Blacktail Pit waste piles occupy similar topographic positions in the two drainage basins. Each waste pile is located at the headwaters of the respective drainage basin and only good quality water from snowmelt or precipitation is available to recharge the waste piles. Waste piles further downstream in the two drainages are recharged by water with high metal ion concentrations and low pH values. Waste rock and low grade ore in both the F. S. and Blacktail Pit waste piles are from the same source, the Blacktail Pit. One would expect water of similar chemical charateristics to originate from both waste piles, given the above similarities of location in the drainage, good-quality recharge water, and source area of waste material. One would alsoexpect that waste piles resulting from future mining operations would yield water with a similar chemical quality if these waste piles were deposited under topographic, water quality, and source area conditions similar to those at the F. S. and Blacktail Pit waste piles. Prediction of water quality originating from future surface mine waste disposal sites is important in designing a water collection and treatment system.

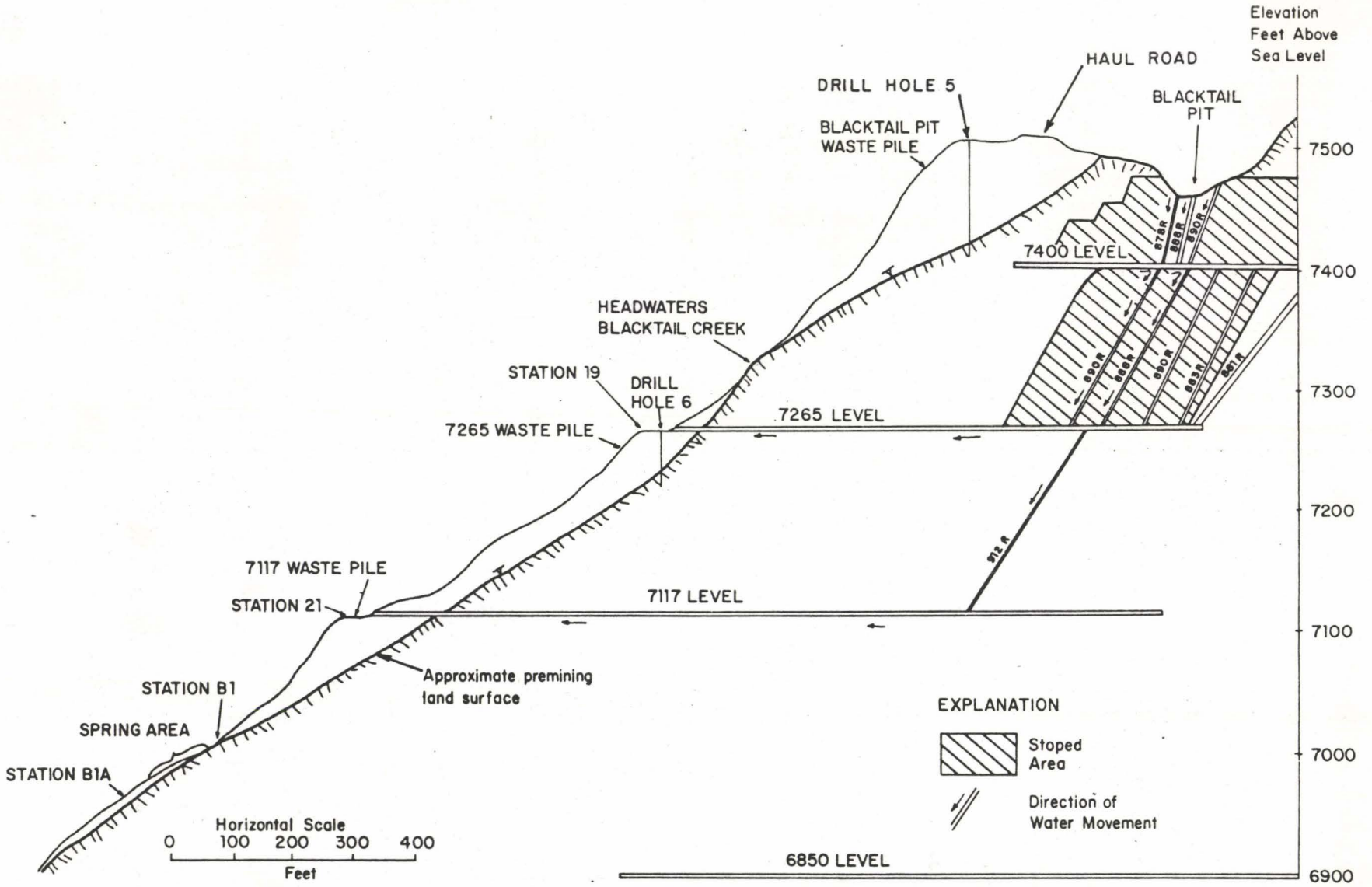


Figure IV-5. Valley profile and approximate location of mine workings in the Bucktail Creek drainage.

Table IV-4. Comparison of water quality between stations 17 and 19 for 1974. Total metal ion concentrations give in parts per million.

Station	Period	pH	E.C.	Co	Cu	Fe	Mn
17	7-21 to 11-02	3.9	2490	60.0	291	0.2	11.6
19	7-21 to 11-02	3.9	4900	212	1680	0.3	35.2

7265 Waste Pile

Waste rock produced from mining on the 7265 level was dumped in a long bench below the portal to form a waste pile with a volume of about 50,000 cubic yards. The 7265 waste pile has filled in the channel of Bucktail Creek for a distance of about 150 feet. Bucktail Creek now flows across the top and down the face of this waste material (Figure IV-1). An abrupt flattening in stream gradient occurs as Bucktail Creek flows across the waste pile. This results in deposition of fine grained sediments on the waste material and limits recharge from the stream to the waste pile. Groundwater levels from DH6 (to be presented later) indicate that Bucktail Creek is perched as it flows across the waste pile.

Field investigations of this waste pile during the spring and summer months showed that no springs or seeps were present near the base of the pile; however, discharge measurements indicated a gain in streamflow between stations 19 and 21 (Figure IV-6). Part of this increased streamflow was due to discharge from the 7265 portal (station 20). When this contribution was subtracted from streamflow at station 21, the gain in streamflow ranged from 13 gpm June 19 to no gain by July 11, 1975. Data for 1974 and 1976 show similar trends between stations 19 and 21. Station 21 is located about 500

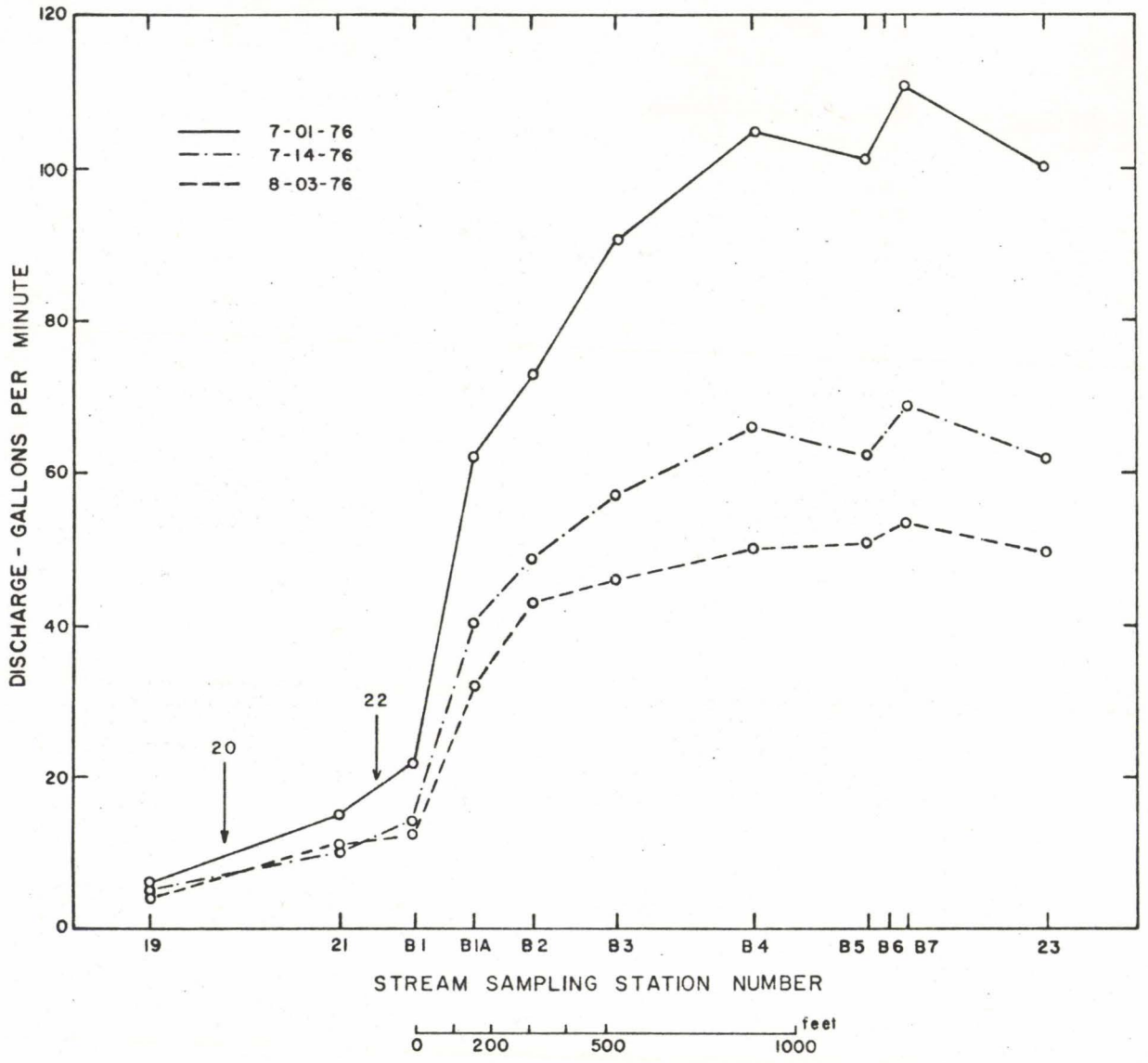


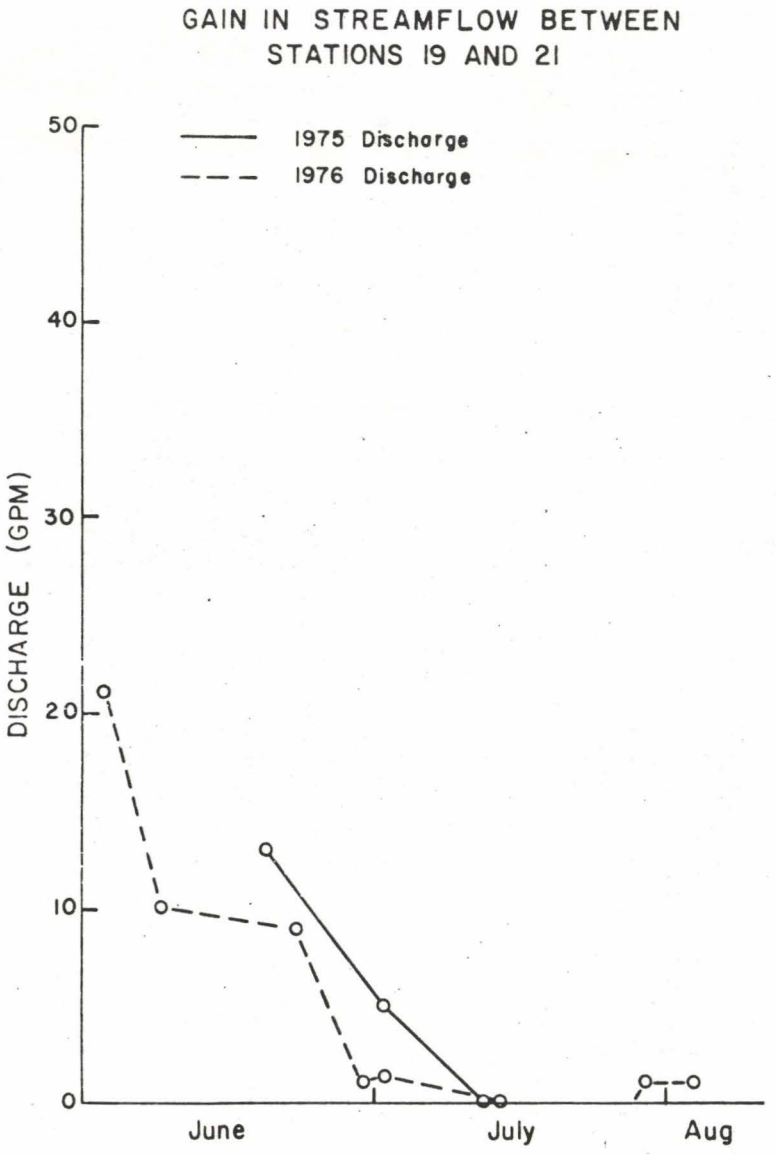
Figure IV-6. Discharge in Bucktail Creek between stations 19 and 23 for 1976.

feet downstream of station 19. The gain in flow may be from drainage from the 7265 waste pile and/or discharge from the undisturbed colluvium in the reach below the waste pile. The temporal plots of gain between stations 19 and 21, presented in Figure IV-7, show that the ground-water flow system is quickly depleted following the spring runoff period.

No point sources of discharge could be identified from the 7265 waste pile so no direct water quality data are available. Water quality at station 21 represents input from the 7265 portal, the gain between stations 19 and 21, and the flow at station 19. Cobalt and copper ion concentrations and pH values decrease from stations 19 to 21 while iron concentrations increase (Table IV-2). Discharge from the 7265 portal is low in cobalt and copper (Table IV-2) and the addition of this discharge to Bucktail Creek causes the decrease in cobalt and copper concentrations noted at station 21. The reverse is true for iron concentations and pH values; the addition of discharge from the 7265 portal causes increases in iron concentrations and lower pH values at station 21. Lower pH values also retard the formation of insoluble iron hydroxide precipitates which results and in higher iron concentrations.

7117 Waste Pile

The 7117 waste pile is similar in size and shape to the 7265 waste pile. This waste pile is composed of waste rock removed during mining operations on the 7117 level. The Bucktail Creek drainage has been filled in for a distance of about 250 feet by this waste material and the creek flows across the top of the waste pile and down the face as it does on the 7265 waste pile. It is believed that the creek is also perched as it flows



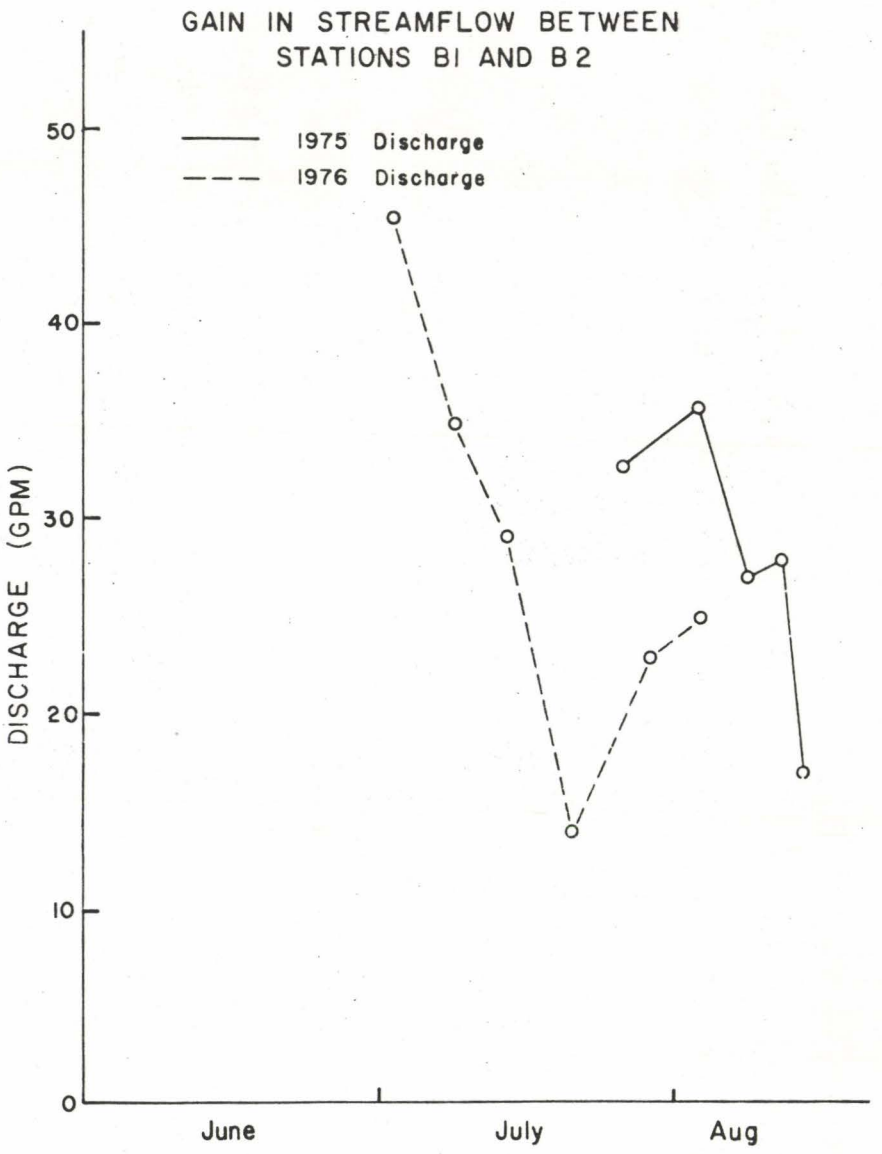


Figure IV-7. Discharge variations between stations 19 and 21 and stations B1 and B2.

over this waste pile; the abrupt gradient change between the natural stream channel and the waste pile causes fine grained sediments to be deposited over the original waste material.

Discharge comparisons between stations B1 and B2 show a marked increase in streamflow along the 300 foot segment of the stream which lies immediately below the 7117 waste pile (Figure IV-6). No surface discharge areas were observed during field investigations of the 7117 waste pile. Discharge at station B2 is the sum of stream discharge at stations B1 and mine drainage from the 7117 portal (station 22). Discharge at station B2 minus the sums of discharge at stations B1 and 22 therefore gives the amount of ground-water inflow to Bucktail Creek between stations 21 and B2. The hydrographs of this discharge for 1975 and 1976 are presented in Figure IV-7B.

The hydrographs shown in Figure IV-7B show an increase in ground-water discharge during August for both 1975 and 1976. This increase occurs during late summer months when recharge is normally quite small. However, monthly precipitation records at Cobalt show that the area received 3.30 inches of precipitation during July, 1975, compared with an average of 1.19 inches for the preceding 10 years of record. For 1976, 2.00 inches of precipitation was recorded during August compared with an average of 1.06 inches for the previous 13 years of record (Table II-5). It is felt that recharge from late summer precipitation events caused the increase in ground-water discharge observed at station B2.

Figure IV-7A shows that discharge variations between stations 19 and 21 are not as pronounced as discharge variations between stations B1 and B2.

A gain in streamflow for 1975 was not detected between stations 19 and 21 after July 11. Streamflow gains noted during July and August of 1976 between stations B1 and B2 were much larger than streamflow gains between stations 19 and 21 for the same period. Similar trends in streamflow gains for the two field seasons suggests that the trend is the result of some physical characteristic of the reach between stations 19 and 21 and is not due to measurement error. It is believed that this lack of response to late summer precipitation is a function of hydraulic conductivity and the degree of saturation of the waste pile material between the two stations. Hydraulic conductivity in the waste pile material is probably lower than in the natural valley fill material. During the spring runoff period large amounts of water are available for recharge. Although the predominant direction of water movement is downward toward the water table, low hydraulic conductivities in the waste pile material may cause some water to move laterally downslope. This water may then appear as ground-water discharge between stations 19 and 21. In addition, the depth to the water table between stations 19 and 21 is about 35 feet below land surface (Figure IV-5) and small water-level fluctuations would not raise the water table sufficiently to intersect the land surface. By contrast, the water table is believed to intersect the land surface between stations B1 and B2 (Figure IV-5) throughout most of year. The ground-water discharge analysis for the reach between stations B1 and B2 (Figure IV-7B) shows that ground-water discharge occurs in this reach during all of the 1975 and 1976 field seasons. Therefore, any recharge to the ground-water flow system in Bucktail Creek should appear as ground-water discharge between stations B1 and B2 while large amounts of recharge would be needed to cause ground-water discharge between stations 19 and 21.

Water quality of ground water discharging between stations 19 and 21 could not be determined directly since this water enters the stream channel over a 300 foot distance as base flow. Subtracting metal load contributions of station 22 and B1 from metal loads at station B2 gives the metal load included in ground-water discharge from the 7117 waste pile. Knowing the amount of this ground-water discharge, one can work backwards to solve for the metal ion concentrations in the water. The values obtained by this method should be viewed as only approximate. Table IV-5 gives metal loads, metal ion concentrations, and discharge values for ground-water discharge between stations B1 and B2 for 1975 and 1976. Metal ion concentrations in this discharge are intermediate between concentrations at stations 19 and 21.

West Fork Waste Pile

A third possible source of acid contribution in the Bucktail Creek drainage is a surface waste feature which will be referred to as the West Fork waste pile, shown in Figure II-3. Waste material from the Blacktail Pit was dumped at the head of the West Fork of Bucktail Creek to serve as fill material for the main haul road from the pit. The volume of this waste feature is probably on the order of 10,000 cubic yards.

The fork of the creek flows for its full length only during spring runoff or during heavy precipitation events. Maximum discharge is estimated to be less than 50 gpm. Springs at an approximate elevation of 7300 feet supply water to the creek but this discharge infiltrates into the stream channel a short distance downstream of the springs. Station B6 was located during the 1975 field season to monitor discharge and water quality from the West Fork Waste Pile.

Table IV-5. Approximate metal loads and metal ion concentrations (in ppm) from 7117 waste pile ground-water discharge for 1975 and 1976 based upon mass balance calculations.

Date	Metal Load (lbs/day) Co	Cu	Metal Ion Concentrations (ppm) Co	Cu	Discharge (gpm)
1975					
7-26	26	210	65	520	33.3
8-01	39	180	90	420	36.0
8-08	34	150	100	460	27.1
8-14	40	130	190	600	17.3
1976					
7-01	46	170	75	270	51.0
7-08	18	160	50	450	29.0
7-14	21	110	70	350	25.0
7-23	25	130	110	570	19.0
7-29	36	130	150	560	20.0
8-03	25	110	110	500	19.0

Surface discharge was recorded at station B6 only once during the 1975 field season, when the discharge was 0.5 gpm. Although sampling was conducted at other times, discharge at this station was considerably less than 0.5 gpm. A discharge of 5 gpm was recorded during mid-August of 1975 upstream of station B6, before the streamflow infiltrated into the streambed. Ground-water discharge from the West Fork of Bucktail Creek does contribute to streamflow on the main stream. Figure IV-6 shows discharge increases occur between stations B5 and B7, Bucktail Creek. This increase discharge must come from ground-water flow since no surface-water flow was recorded from the West Fork during the 1976 field season. This component of discharge ranged from 2 to 10 gpm.

Analysis of water samples collected at station B6 shows that discharge from this section of the Bucktail Creek drainage is good quality. Much of the discharge measured at station B6 would pass through the West Fork Waste Pile. The West Fork Waste Pile was deposited at the headwaters of the West Fork of Bucktail Creek (Figure IV-1). This waste pile occupies about 500 feet of the headwaters of the West Fork. Water quality at station B6 would be similar to that at station 19 if leaching of metal ions from the West Fork Waste Pile was occurring. Good quality water at station B6 indicates that there is no production of acid drainage; therefore, no low grade ore or sulfide minerals must have been deposited in this waste pile.

Seep Zones

Two ground-water discharge areas are present along Bucktail Creek in-between stations B1A and B3. Both zones are approximately 50 feet wide at the base and extend up the valley slope on the north side of the Creek (Figure IV-2). The soil and forest cover in both zones was saturated in

1975 but discharge was limited to a trickle of water. A third zone, located further downstream of the first two (Figure IV-2), was later determined to be the result of slumping or similar earth movement.

Both seep zones were initially identified by dead vegetation and trees which outlined the area. No sample analysis was conducted on water from the zones but electrical conductivity values varying from 1500 to 2000 micromhos were recorded from both zones indicating that poor quality water discharges at both areas. Stations B1 and B4 were initially located to determine if these seep zones were contributing measurable amounts of poor quality water to Bucktail Creek. Data from these stations indicate that most of the increased discharge entered Bucktail Creek above the upper seep zones and the zones did not contribute measurable amounts of poor quality water to the creek.

Mature dead trees in both zones indicates that poor quality water has only recently begun to discharge at these points, possibly within the last 10 years. It is hypothesized that mining in the Blacktail Pit has exposed fault or fracture zones which are mineralized and that the two seep zones along Bucktail Creek are the surface expression of these faults as they cross the creek. Recharge entering the faults leaches metals from sulfide minerals and discharges at the seep zones along Bucktail Creek. Detailed geologic mapping has not been completed in the Bucktail Creek drainage and this hypothesis can not be supported.

Mine Workings

7265 Level

The variables discussed in Chapter III which control the production of acid mine drainage most certainly are applicable to the mine workings

in the Bucktail Creek drainage. The 7265 level lies directly beneath the Blacktail Pit and receives discharge from the pit via the 896R. The amount of recharge entering the 7265 level in this manner may be quite small, however. The highest discharge recorded at station 20 (7265 portal) was 12 gpm during 1969, while the average discharge for four years was 4.2 gpm. The existence of a direct recharge connection between the Blacktail Pit and the 7265 level was demonstrated during the 1975 field season when lime was used as a tracer. The lime was mixed with water and allowed to run into the pit, and discharge from stations in the vicinity of the pit was monitored for a two-day period. One-half hour after the lime was introduced into the pit, the mixture was observed flowing through fractures to the 7400 level, and then flowing down the 896R to the 7265 level. One hour after the test started, the lime mixture was observed at station 20 (the 7265 portal). The lime mixture was not observed in discharge at either the 7400 portal or the 7117 portal (stations 15 and 22) during the two-day period.

Most of the recharge to the 7265 level is believed to come from ground-water discharge to the mine workings because of the relatively constant discharge from the 7265 portal. Much of the recharge to ground-water flow systems which the 7265 workings penetrate probably originates in the Blacktail Zone. Annual discharge from station 20 is approximately 6 acre-feet/year.

Water quality at station 20 is shown in Table IV-2. Metal ion concentrations are lower than those at station 19 (Blacktail Pit waste pile) but higher than those at station 22 (7117 portal). Values for pH are lower than at either station 19 or 22. These intermediate metal ion concentrations reflect the leaching of metal ions from the Blacktail Zone and stoped areas between the 7265 and 7400 levels. Some dilution may occur through intermixing of poor-quality water from mined areas and good-quality

ground water from the fractured rock systems. The mechanisms which foster low pH values in mine workings are not completely understood but may involve iron bacteria as discussed previously in Chapter III. Table IV-6 lists total metal loads and discharge from the 7265 and 7117 levels and the upper Bucktail Creek drainage for 1975. Metal loads at the 7265 portal are much higher than those at the 7117 portal.

Table IV-6. Estimated total metal load and discharge from the 7265 and 7117 portals (stations 20 and 22) for the 1975 water year.

Station	Discharge (acre-ft/yr)	Metal Load (lbs)		
		Co	Cu	Fe
20 (7265 portal)	6	2,500	3,500	4,000
22 (7117 portal)	6	200	200	300
23 Bucktail Creek	80	9,000	35,000	300

7117 Level

Figure IV-5 shows the relationship of the 7117 level to other mine features in the Bucktail Creek drainage. The 912R connects the 7117 and 7265 levels; deteriorating mine workings on both levels prohibited extensive underground investigations. Based on results of the tracer experiment conducted during 1975, it is believed little if any recharge to the 7117 level passes through the 912 raise. Therefore, most discharge to the 7117 level is from ground water. This discharge may originate as recharge introduced into ground-water flow systems through the Blacktail Pit, or it might come from naturally occurring ground water in the fractured rock system.

Water quality characterisitics at station 22, (Table IV-2 and IV-6) show that metal ion concentrations here are much lower than at station 20 (7265 portal). These lower metal ion concentrations may indicate that the

7117 level is isolated from ground-water flow systems associated with the Blacktail Pit. If this is correct, then metal ions in solution at station 22 were leached from ore zones in the immediate vicinity of this level from ore exposed in the drifts and raises on the level. The lower metal ion concentrations may also reflect the fact that fewer stoped areas exist above the 7117 level, and thus less sulfide mineralization is exposed to oxidation and leaching. Plate I shows that there are no stoped areas between the 7117 and 7265 levels. Two small stopes do exist, but these were not shown on the diagram. Table IV-6 shows that the metal load contributed to Bucktail Creek from the 7117 level is small.

Mine Drainage and the Blacktail Pit

Comparison of water quality data from mine workings for 1975 (Table IV-7) shows that discharges from the 7265 and 7400 levels are high in cobalt and copper concentrations while discharges from the 7117 and 6850 levels contain lower concentrations of cobalt and copper. Water quality data from 1969 and 1974 show a similar trend for portal discharge. Values shown in Table IV-7 are averages for the field season and therefore take into account concentration variations which occur during the year. The data show that mine workings in close proximity to the Blacktail Pit have correspondingly high cobalt and copper concentrations while workings isolated from the pit have lower cobalt and copper concentrations.

Table IV-7. Average water quality of portal discharge in the Blackbird Mining area.

Station	Average pH	Average E.C.	Average Metal Ion Concentrations (ppm) Co	Cu	Fe
7 (6850)	2.6	1390	21.1	45.0	150
15 (7400)	2.8	1590	66.4	298	66.4
20 (7265)	2.8	1750	125	161	183
22 (7117)	2.9	970	28.9	22.4	35.9

The averages for iron concentrations show that this ion does not follow the trends of cobalt and copper concentrations.

Ratios of annual discharge to total length of mine workings were computed for the various portals to determine if some portals were producing a higher proportion of discharge than others. Drainage from several levels may flow to a common discharge point. Therefore, several levels may contribute to the discharge at a single portal. In general, the 6850 portal drains levels 6600 through 7300, the 7400 portal drains levels 7400 through 7675, and the 7117 and 7265 portals drain the 7117 and 7265 levels respectively. The 7117 and 7265 levels are very much alike with respect to discharge characteristics. Annual discharge from the two portals was the same (6 acre-ft/yr) and the length of workings on the 7117 and 7265 levels was about equal. The discharge per length of mine working is about equal for each portal. Therefore, the two levels were treated as a single drainage system and the two portals were treated as a single discharge point for this discussion.

The data show that more discharge per foot of mine working occurs from the 7400 and 7117 and 7265 portals (Table IV-8). These portals drain levels which are close to the Blacktail Pit, and the pit may be responsible for a

portion of this additional drainage. However, these levels are also nearer to the top of the ridge where greater amounts of snow accumulate during winter months. These levels are also nearer to the ground surface where recharge is intercepted before it reaches lower levels. Greater precipitation during 1976 (Table I-1) is reflected in more discharge from all portals. Table IV-8 shows that a large increase in discharge from the 7117 and 7265 portals took place from 1969 to 1976. This increase may reflect the loss of sand fill from workings beneath the pit and a greater potential for direct recharge to mine workings. Consideration should be given to these data when planning future development of mine workings at higher elevations in the mining area. As much as 50 percent more discharge per foot of workings can be expected at higher levels than for levels deeper in the mountain.

Ground Water in the Bucktail Creek Drainage

Drill Hole 5

Ground-water quality and water levels in the Blacktail Pit waste pile were monitored at drill hole 5 (DH5). The location of this drill hole is shown in Figure II-4 while Figure IV-5 shows the cross sectional relationship of this drill hole to other features in the area. The drill log and construction details for the piezometers are shown in Plate II. Wood fragments were encountered at a depth of about 85 feet. Drilling was stopped at 91.3 feet below land surface where solid rock was encountered. The 85 foot depth is believed to represent the original surface of the valley floor before deposition of the Blacktail Pit waste material.

Table IV-8. Discharge per foot of working for portals draining the Blackbird Mine

Length of Workings (feet)		Year	Annual Discharge (gal)	Discharge per Foot of Workings (gal/foot/yr)
		6850 Portal (6600 through 7300 Levels)		
Drifts	31,400	1969	1.69×10^7	360
Raises	15,100	1976	2.05×10^7	440
Total	46,500			
		7117 and 7265 Portals (7117 and 7265 Levels)		
Drifts	3,300	1969	2.6 xx 10^6	620
Raises	900	1976	3.9×10^6	930
Total	4,200			
		7400 Portal (7400, 7540 and 7675 Levels)		
Drifts	5,400	1969	4.6×10^6	740
Raises	800	1976	4.9×10^6	790
	6,200			

Water Level Fluctuations

During the 1976 field season, water levels in DH5 stood at about 84.25 feet below land surface (Figure IV-8). The contact between the waste pile and the original valley fill could not be accurately determined but the phreatic surface may actually stand at nearly the same level as in the pre-waste valley fill material.

Water levels in DH5 declined 0.64 foot from July through mid-September of 1976 (Figure IV-8). Declining water levels represent the drainage of water from the valley fill material in the absence of inflow. Domenico (1972, p. 48) uses the term recession to describe this process. Though there was an overall drop in water levels during the 1976 field season, a water-level rise of 0.15 foot was noted throughout July. This mid-summer water-level rise may have resulted from delayed ground-water flow from snow melt recharge.

Water Quality

Average water quality parameters of samples collected from DH5 are shown in Table IV-9. The data show that average copper concentrations are very low while iron concentrations are extremely high, when compared with water quality data from discharge points such as stations 17 and 19. During the drilling procedure, a five foot length of NW casing was lost at the bottom of DH5; it is believed that corrosion of this section of casing results in high iron values and possibly causes copper to precipitate out of solution.

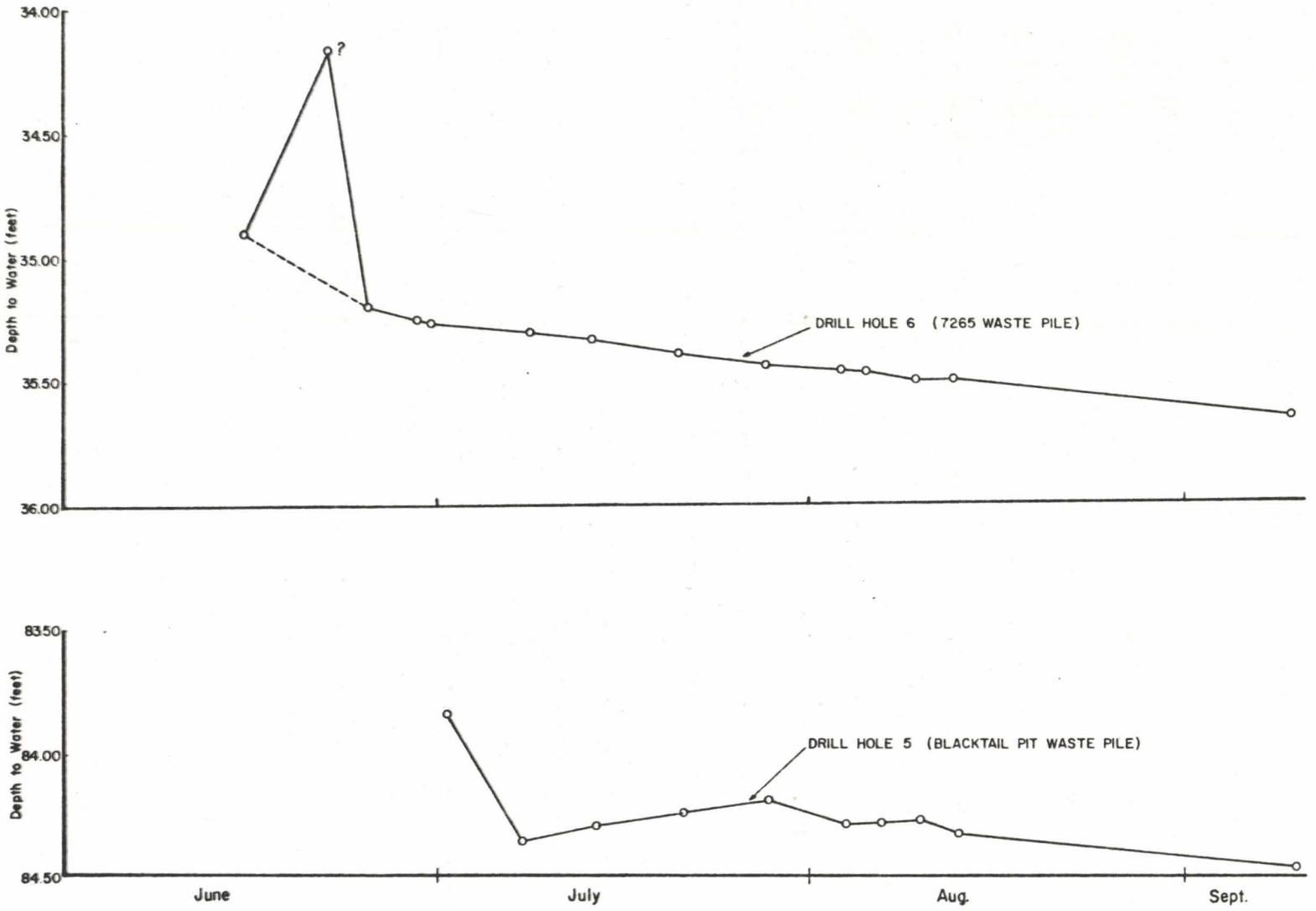


Figure IV-8. Water levels for drill holes 5 and 6 for the 1976 field season.

Table IV-9. Average water quality parameters of samples collected at drill holes 5 and 6 during the 1976 field season. Metal ion concentrations are given in parts per million.

Drill Hole	pH	E.C.	Co	Cu	Fe	Mn	Mg	Ca	Na	Number of Samples
5	4.0	4280	254.0	5.2	2230.0	43.1	370.0	153.0	16.2	5
6	4.2	2980	375.0	805.0	10.4	23.7	208.0	86.0	12.4	7

Metal ion concentrations at DH5 decreased during the course of the field season. Cobalt concentrations decreased from 507 ppm on July 7 to 110 ppm on August 3, and copper concentrations decreased from 9.2 ppm on July 7 to 1.9 ppm on August 3. Water from spring snowmelt percolates down through the Blacktail Pit waste pile and leaches metal ions. This recharge decreases rapidly following the snowmelt period and decreasing volumes of poor-quality water result in decreasing metal ion concentrations at DH5.

Drill Hole 6

Drill hole 6 was completed in the 7265 waste pile about 20 feet from Bucktail Creek (Figure II-4). Figure IV-5 shows the cross sectional location of this drill hole. Construction details for the piezometers are shown in Plate II. Material encountered at 41.6 feet is believed to be colluvium at the original land surface before deposition of waste rock in the Blacktail Creek Drainage.

Two piezometers, DH6S and DH6D, were installed in this drill hole. Piezometers DH6D was perforated frm 26.6 feet to 41.6 feet. The hole was back filled with silica sand; a 3 foot bentonite seal was placed in the hole from 26.6 to 23.6 feet. Piezometer DH6S was perforated from 15 to

8 feet with the hole back filled with silica sand. A 0.5-foot bentonite seal was placed at the surface of the hole to prevent entry of surface runoff water.

Water Level Fluctuations

Water level measurements in the two piezometers showed that at this location, the 7117 waste pile was unsaturated from the surface to a depth of approximately 35.4 feet. Although the drill hole is located only 20 feet from Bucktail Creek, standing water was never detected in piezometer DH6S. Therefore, Bucktail Creek is perched as it flows across the surface of the waste material. A coating of iron hydroxide is present along the creek bed. This precipitate forms a concrete-like coating on rocks and sediment in the streambed and is believed to seal the alluvial material and prevent stream infiltration into the waste pile.

Figure IV-8 shows water-level fluctuations in piezometer DH6D. With the exception of one measurement, water levels declined continuously during the course of the field season. It is believed that ground water monitored at piezometer DH6D is flowing in pre-mining valley fill material. Figure IV-5 shows the stream profile along Bucktail Creek and the approximate location of the water table in the stream channel alluvial material, based on water levels in drill holes 5 and 6.

Water Quality

Average water quality parameters at DH6D for the 1976 field season (Table IV-9) show that copper concentrations are high while iron concentrations are relatively low. This water type is similar to that observed at station 19 and probably represents water quality conditions in the alluvium more accurately than water samples collected at DH5.

No trend in metal ion concentrations is apparent at this drill hole, in contrast to other drill holes, where increasing or decreasing metal ion concentrations were noted during the course of the summer. Constant metal ion concentrations may indicate that ground water moving past DH6 percolates through mine waste material where a constant leaching of metal ion occurs. An alternative explanation might be that a constant volume of poor-quality water moves downward to the water table where intermixing occurs. This latter explanation is thought to be incorrect in view of the wide fluctuations in discharge over the summer.

Water-Quality Variations in the Bucktail Creek Drainage

Seasonal Variations

Water-quality variations at stations along Bucktail Creek follow trends noted in the Meadow Creek and Blackbird Creek drainages. Figures IV-9 and 10 show metal ion concentrations at station 23 for the 1974, 1975 and 1976 field seasons. Metal ion concentrations are lowest on the falling limb of the discharge hydrograph, when accumulated oxidation products have been flushed away and acid discharge is diluted by the spring runoff. Less discharge is available to dilute acid drainage in the late summer low flow period, and metal ion concentrations increase. Heavy snow accumulations prevented access to the drainage during the spring. The quality variations during the rising limb of the discharge hydrograph were thus not determined. It is probable that an initial rise in metal ion concentrations accompanied the first part of the spring runoff similar to that noted in the Blackbird Creek drainage.

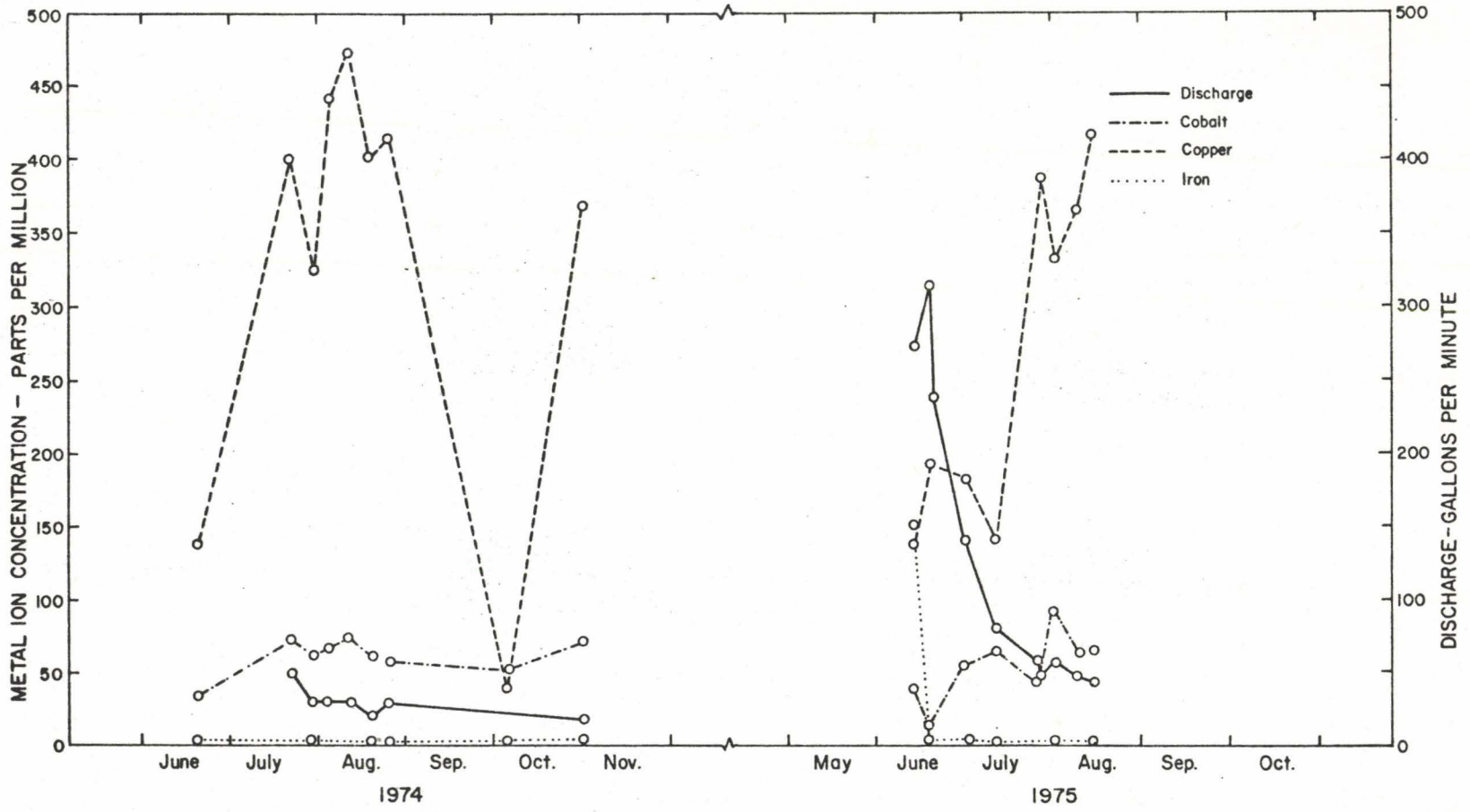


Figure IV-9. Total metal ion concentrations for June to November, 1974 and June to August, 1975 at station 23 (Bucktail Creek).

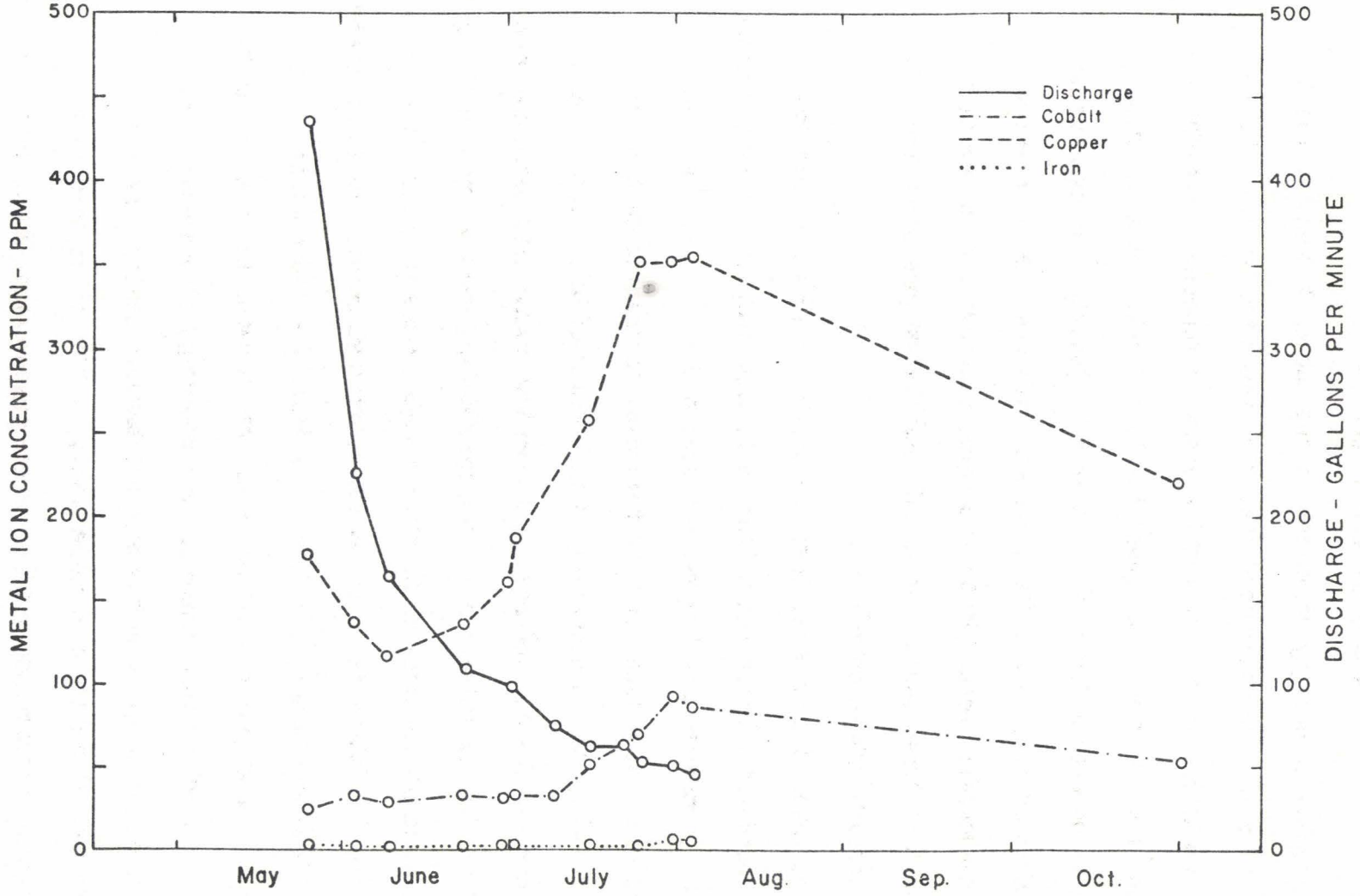


Figure IV-10. Dissolved metal ion concentrations for the 1976 field season at station 23 (Bucktail Creek).

Downstream Variations

Downstream water quality variations along Bucktail Creek are best shown by considering the metal load that the stream transports. Figure IV-11 shows variations in copper metal loads as a function of downstream position for nine stations along upper Bucktail Creek. Sample stations are plotted in downstream order from station 21 (Bucktail Creek) at the 7117 waste pile to station 23, the lowest station where discharge was monitored on Bucktail Creek. Point discharge sources of acid drainage entering Bucktail Creek (such as station 22 and discharge below the 7117 waste pile) are not shown on this graph.

The figure shows that metal loads at upper stations are relatively low until ground-water discharge below the 7117 waste pile enters the creek. The metal loads more than double between stations B1 and B2. The metal loads remain constant between station B3 and B4 indicating that no loss of metals by precipitation occurs along this reach of the stream. The average copper metal load decreases by 55 pounds or about 20 percent between stations B4 and B7. Examination of discharge during the same period (Figure IV-12) shows that streamflow is lost to the alluvium between stations B4 and B7. This infiltrating water contains dissolved metal ions and therefore part of the decreased metal load noted at station 23 is due to this loss. Forty percent of the copper metal load lost between the two stations can be accounted for by a loss in discharge. The remaining 60 percent of the 55 pound decrease probably precipitates out between stations B4 and B7.

Additional metals are precipitating out of solution onto the streambed between stations B4 and B7. Field observations along Bucktail Creek shown that iron hydroxide precipitates increase below station B6.

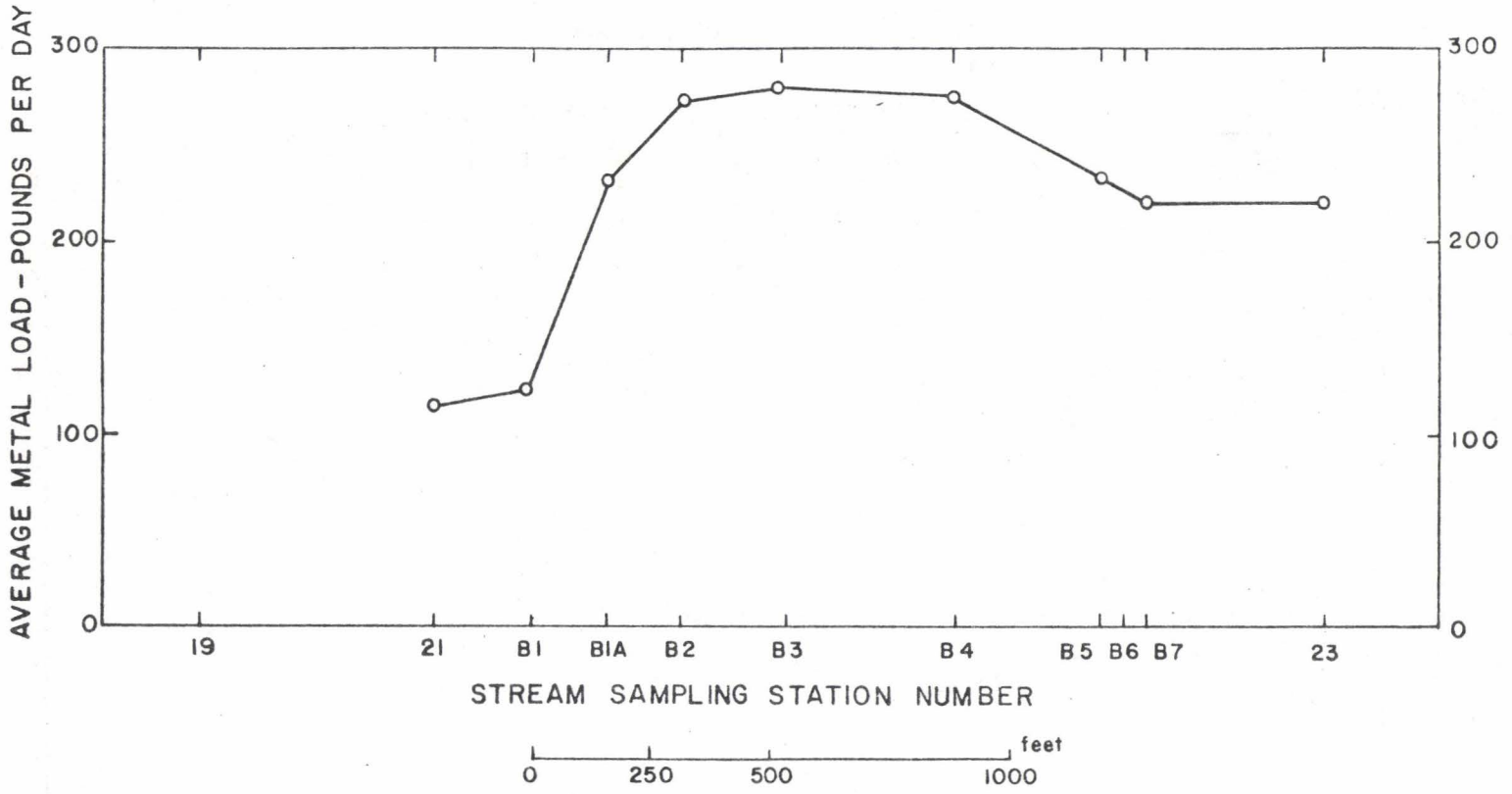


Figure IV-11. Average copper metal load in pounds per day along Bucktail Creek for the period August 1 to August 14, 1975.

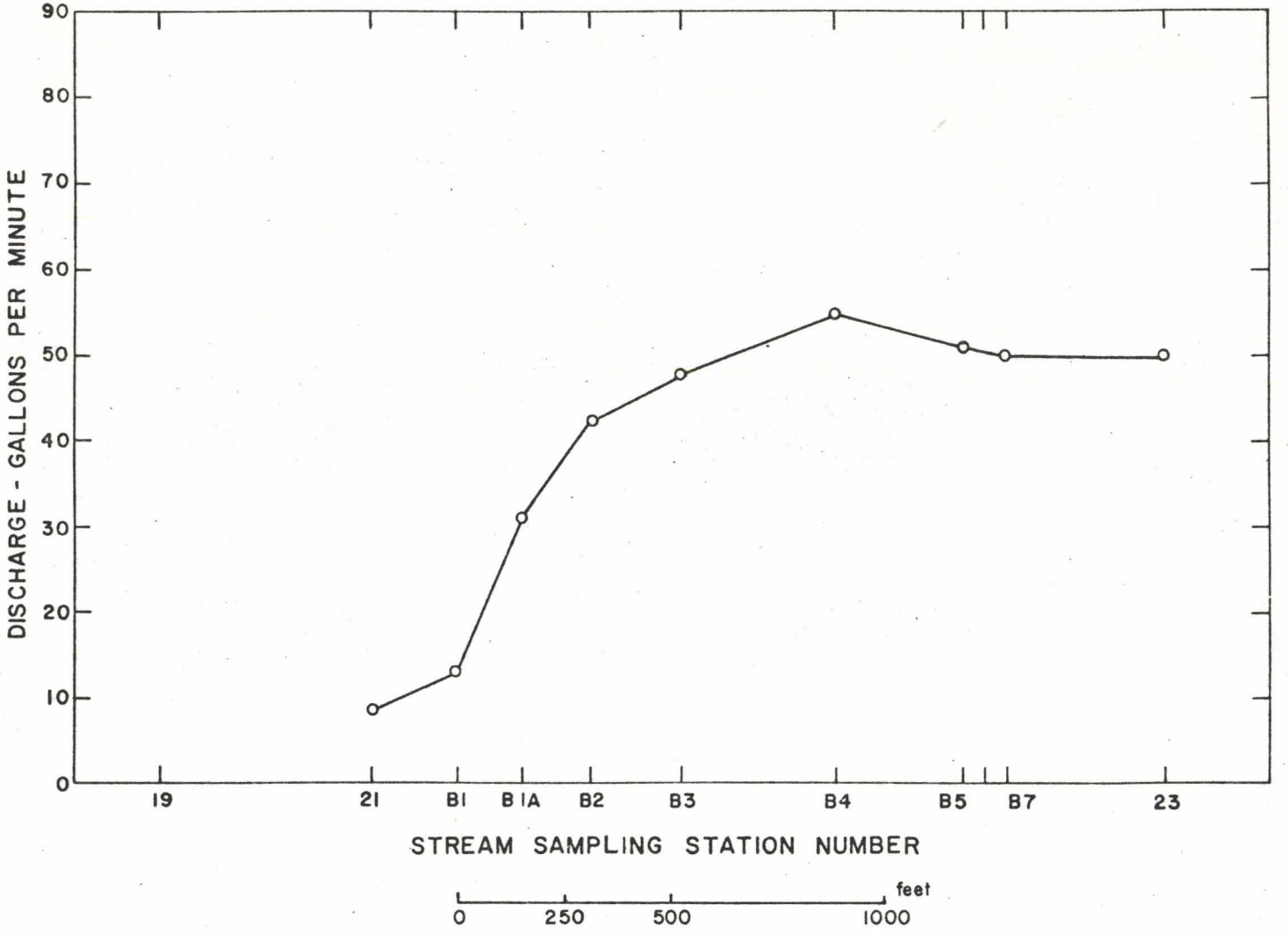


Figure IV-12. Average discharge in gallons per minute along Bucktail Creek for the period August 1 to August 14, 1975.

Good-quality ground water entering Bucktail Creek at station B6 could raise the pH of the water sufficiently to cause precipitation of metals. However, stream discharge averages shown on Figure IV-12 do not show an increase in discharge below station B6.

The water quality downstream of station 23 is assessed in terms of metal ion concentrations since no stream gaging stations were established along the lower reaches of the creek. Metal ion concentrations decrease sharply downstream of station 23 (Figure IV-13). Numerous springs dicharge into this lower section of the creek resulting in dilution of metal ion concentrations. Some of the decrease in concentrations is also due to precipitation of metals out of solution. These precipitates form thick coatings on rocks and debris in the stream channel. The bright blue copper precipitates are most noticable and coat the stream channel of lower Bucktail Creek and the South Fork of Big Deer Creek. These precipitates are believed to be a copper-cobalt sulfate. Precipitation is caused by the inflow of good quality water which raises the pH of water. Copper precipitation in particular is closely controlled by pH in the range 5.0 to 5.5. Additional dilution and metal precipitation results from the mixing of Bucktail Creek and the South Fork of Big Deer Creek, and Big Deer Creek (stations 26 and 28, Figure IV-13). Metal ion concentrations are generally below maximum standards set for drinking water below station 26. Even these low metal ion concentrations have an adverse effect. Field observations by the author show that while trout were abundant in Big Deer Creek above station 28, none were observed in a one mile stretch of Big Deer Creek immediately below station 28.

Total Metal Production

Metal loads at station 23 can be calculated for specific periods where both metal ion concentrations and streamflow measurements were recorded,

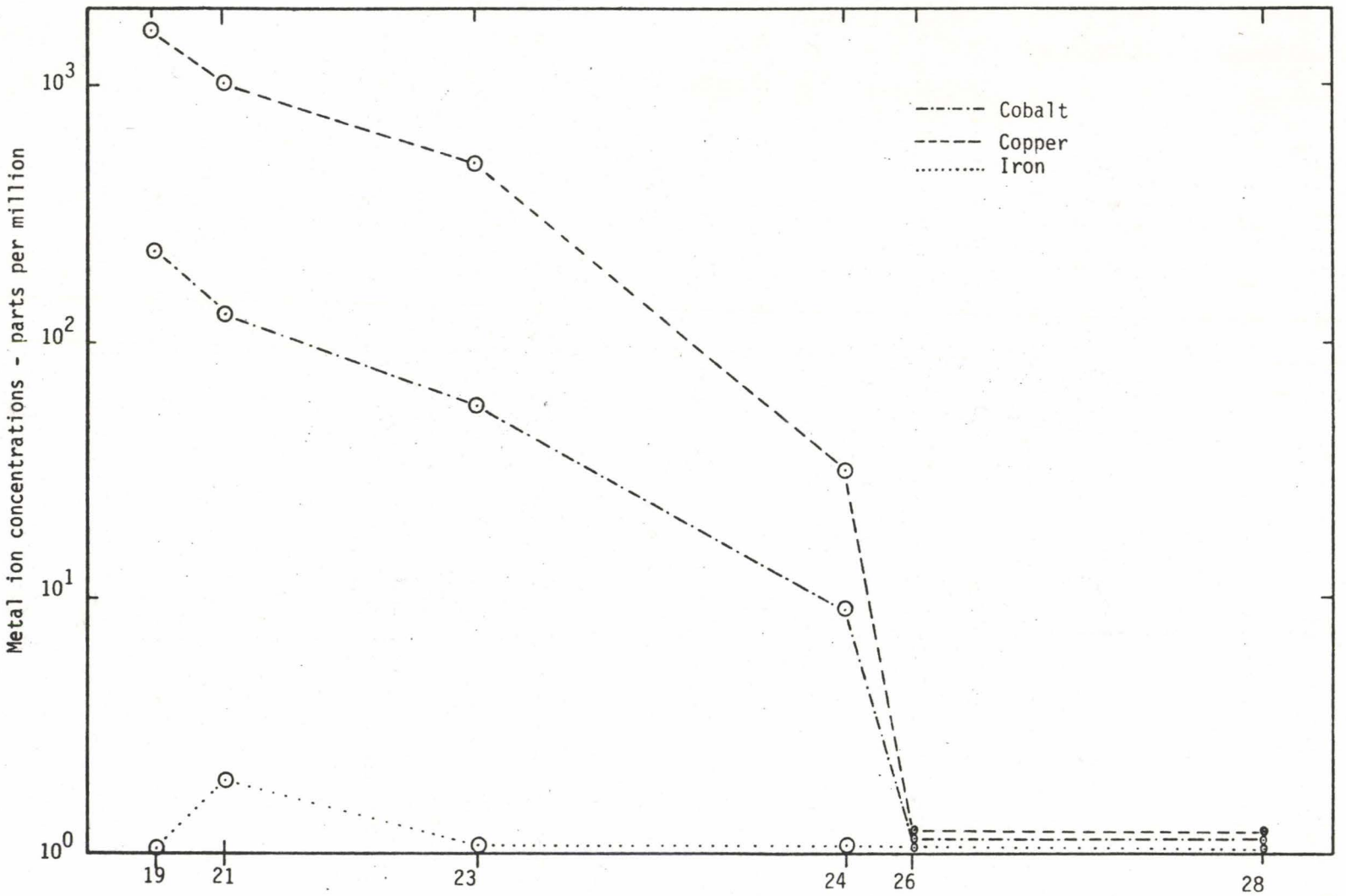


Figure IV-13. Average metal ion concentrations for stations 19 through 28 for the period July 21 to November 2, 1976.

and estimated for annual periods when sufficient data are available during the year. Metal loads for annual periods were estimated by projecting discharge values and metal ion concentrations where data were not available.

Table IV-10 presents cobalt and copper metal loads in tons for various periods of 1969, 1974, 1975, and 1976. The data show that dissolved copper production was approximately 17 tons during 1976. Total copper production, which includes both dissolved and suspended copper, is probably significantly higher. Metal loads for Bucktail Creek (station 23) and Blackbird Creek (station 4) may be comparied on Tables IV-10 and III-8. Although data for station 4 are given for the 1976 water year and data for station 23 are given for the 1976 calendar year, the data are roughly comparable since a low flow - high flow - low flow sequence is included in each period. The data show that copper loads are higher at station 23 while cobalt loads are higher at station 4. Discharge for the 1976 water year for stations 4 and 23 was 5,800 acre-feet and 97 acre-feet respectively.

Table IV-10. Calculated and estimated metal loads at station 23 for various periods.

Year	Period	Metal load (tons) Co	Cu
1969[a]	4-26 to 9-30	5.5	11.0
	1-01 to 12-31[c]	6.5	13.0
1974[a]	7-21 to 11-02	1.0	6.4
1975[a]	6-15 to 8-15	1.8	9.3
1976[b]	5-22 to 11-01	3.8	15.5
	1-01 to 12-31[c]	4.9	17.5

[a] Metal load is total metals
[b] Metal load is dissolved metals
[c] Estimated metal load

Summary

Graphs of metal ion concentrations vs time show that metal production is dependent on discharge and follows the same pattern noted in the Blackbird Creek drainage. Discharge at stations 17 and 19 (F. S. and Blacktail Pit waste pile) have low iron concentrations and moderate pH values, in contrast to all other point source discharge stations which have low pH values and high iron concentrations. Factors which may contribute to the water type observed at stations 17 and 19 are: (1) no recharge from acid mine drainage due to a location at the head of a drainage basin, (2) a common source of waste rock and low grade ore in both waste piles, and (3) similar chemical reactions in both waste piles.

Two seep zones on Bucktail Creek discharge small quantities of poor quality water. These areas may be the surface expression of fault or fracture zones which carry poor quality water from the vicinity of the Blacktail Pit.

Based on water quality parameters, the 7117 level appears to be hydrologically isolated from ground-water flow systems associated with the Blacktail Pit, while the 7265 level appears to be hydrologically connected with the Blacktail Pit and the 7400 level. Mine workings at higher elevations produce as much as 50 percent more discharge per foot of mine working per year than mine workings at levels deeper in the mountain.

Ground-water quality in the upper Bucktail Creek drainage is similar to surface water. Water quality parameters and water level fluctuations indicate that surface water and ground water are closely interrelated. Annual cobalt and copper loads at stations 4 and 23 (Blackbird and Bucktail Creeks) are similar, but annual discharge at station 4 is 40 to 50 times greater than at station 23. Iron loads at station 4 are approximately 100 times greater than at station 23.

CHAPTER V

CONCLUSIONS AND RECLAMATION ALTERNATIVES

Conclusions

Total Discharge

Total discharge from the Blackbird Mining area for the 1976 water year was about 5,900 acre-feet, with about 5,800 acre-feet of this discharge from Blackbird Creek (station 4) and about 100 acre-feet from Bucktail Creek (station 23). In Blackbird Creek, acid drainage totaled about 420 acre-feet from Meadow Creek (station 10A) and 63 acre-feet from the 6,850 portal (station 7) for the 1976 water year; the remaining 5,320 acre-feet measured at station 4 was good-quality water from Blackbird Creek above the mill (station 7) and small tributaries between stations 4 and 6. Only about 50 acre-feet of the 420 acre-feet measured at Meadow Creek is actual acid mine drainage from point discharge sources; the remaining 370 acre-feet is good-quality water from snowmelt runoff and Meadow Creek above the F. S. Waste Pile (station 16). The entire 100 acre-feet of discharge measured in the Bucktail Creek drainage (station 23) is acid mine discharge. This gives a total of 213 acre-feet of acid mine drainage from point discharge sources in the Blackbird Mining Area for the 1976 water year.

Discharge-Metal Ion Relationships

Stream discharge and water quality are closely interrelated in the Blackbird Mining Area. Discharge-metal ion relationships show that heavy metal concentrations are: (1) low during winter months, (2) increase

sharply during the initial spring runoff period, (3) are very low during the latter part of the spring runoff, and (4) rise gradually during later summer months. As much as 75 percent of the total annual metal production occurred during April and May of 1976. This large output of heavy metals during a short time period occurs each year.

Acid Production: Underground Workings

Acid production from underground workings is controlled by: (1) oxygen, (2) availability of pyrite and other heavy metals, (3) moisture in the mine atmosphere, (4) availability of water to transport oxidation products, and (5) mine characteristics (Trexler and others, 1975). An additional variable may be the presence of iron bacteria which facilitate the oxidation of Fe^{2+} to Fe^{3+}. Variables 4 and 5 can be managed to reduce or eliminate acid mine drainage from the underground workings.

Several raises in the Blackbird Creek drainage intersect the ground surface and receive direct recharge from surface runoff and ground-water discharge from shallow ground-water flow systems recharged by snowmelt. Recharge to mine workings also occurs in areas where Meadow Creek is above workings on the 7100 and 7200 levels. Oxidation of sulfide ore minerals takes place continuously. Flood events flush the oxidation products out of the mine. In the Bucktail Creek drainage, the 7265 and 7400 levels are hydrologically connected with flow systems associated with the Blacktail Pit. Workings at the 7117 level are isolated from these flow systems. Mine workings at higher elevations produce greater quantities of discharge than do workings at lower elevations in the mountain.

Acid Production: Surface Waste Features

Acid production from surface waste features is governed by the following variables: (1) oxygen, (2) availability of pyrite and other heavy metals, (3) moisure in the waste material, (4) availability of water to transport oxidation products, (5) physical location of the waste feature, and (6) presence of iron bacteria. Variables 4 and 5 may be managed to reduce acid drainage from surface waste features.

The F. S. and Blacktail Pit waste piles produce water with significantly lower iron concentrations and lower total iron loads than waste piles located at lower elevations in the Meadow and Bucktail Creek drainages. Waste features located at lower elevations are recharged by acid water with high metal ion concentrations and low pH values. Acid production from tailings and waste rock deposited in stream channels is a significant source of heavy metal production in the Meadow Creek drainage.

Reclamation Alternatives

Reduction of acid production from present surface and underground features can be accomplished by inititating various maintenance procedures. Future mining activities should incorporate hydrological variables in mine planning and surface waste site selection procedures.

Underground Workings

Field investigations have shown that mine characteristics and availability of water to transport oxidation products out of the mine are factors which can be controlled to reduce acid mine drainage.

Mine Characteristics

All raises intersecting the ground surface should be carefully inspected for signs of recharge from both surface and ground water. This inspection

should include the following raises: 506R, 527R, 598R, 607R, 619R, 622R, 663R, 669R, and the 706 VR. Any additional raises intersecting ground surface which are not shown on mine diagrams should also be inspected for signs of recharge. Many of these raises have been sealed against direct surface water recharge in the past three years. Water seeping into the raises from saturated soils and colluvium may be prevented by grouting around the outside of the raise to a depth of 8 to 10 feet. This would apply to raises located in areas where ponding or direct surface-water flow exists. Particular attention should be payed to the 706VR. This raise has not been sealed and the raise is forming an increasingly large pit as sloughing occurs along the sides.

Mine characteristics contributing to recharge to mine workings in the Bucktail Creek drainage will be very difficult to correct. One possible solution would be to seal the bottom of the Blacktail Pit to eliminate direct recharge to the 7400 and 7265 levels. Water would then pond in the pit and seepage through the pit walls would take place unless the walls were also sealed. Seepage through the pit walls would probably leach heavy metals from the ore zones. Metal production might be increased if this procedure was used. The above problems could be avoided if the Blacktail Pit were filled in with waste rock to an elevation of about 7,520 feet, about eight feet higher than the haul road at the western end of the pit. Figure IV-5 shows the cross sectional view of the pit and the haul road at the mouth of the pit. If the pit was filled to an elevation higher than the road, surface water would drain out of the pit area, across the haul road and down the Blacktail Pit waste pile. The fill material should

be revegetated to prevent erosion and excessive infiltration and the haul road should be culverted to allow runoff to pass under the road.

Availability of Water to Mine Workings

Reducing or redirecting water flow in the mine should also reduce metal loads discharging from the mine. A first priority should be to grout or cap all flowing drill holes on all levels, especially the 6850 level. This could easily be done and would result in an immediate reduction of 16 acre-feet of water at the 6850 portal as shown in Chapter III.

Maintenance work should be continued on all levels to prevent ponding of water and flooding of ore filled raises, such as on the 7200 level. During spring runoff ponding occurs on levels which are blocked by cave-ins or excessive accumulations of iron hydroxide precipitates. Water may pond up until it flows down raises that are normally dry. Oxidation products are then flushed out of the raises. Water discharging from raises to the 7100 and 7200 levels should be traced back to its origin and appropriate maintenance steps should be undertaken to reduce this flow. Water should be prevented from flowing through stopes or raises containing oxidized ore where production of acid salts is potentially high. In many cases this would involve erecting and sealing a bulkhead at the entrance to the stope or raise, while in other cases this would merely involve cleaning out the drainage ditch on the level to allow water to flow freely along the level.

Diversion of discharge to central flow points within the mine workings would help to eliminate flushing of accumulated oxidation products or contamination of good-quality discharge sources. Discharge from the 7400

portal could be diverted down the Brown Bear shaft and down raises to the 6850 level. Diversion of this flow down the Brown Bear shaft would not result in any additonal metal leaching since the shaft is fully timbered. Such a diversion could only be considered a temporary solution since the timbering in the shaft will deteriorate with time. This discharge and water flowing to the shaft from other levels could be directed to the 6850 level down raises which do not contain oxidized ore. The drainage system on the 6850 level could handle this increased discharge if flowing drill holes on the 6850 level were capped. There should be no net increase in discharge at the 6850 portal since the annual discharge from the drill holes is about equal to flow on the 7400 level. As an additional advantage in this diversion, discharge from the 7400 portal would no longer be available to leach metals from waste piles and mine debris in the Meadow Creek drainage, resulting in decreased metal production from this source. Decreased metal production should be especially apparent during low flow periods when the 7400 portal is the major source of poor quality in the upper Meadow Creek drainage.

A second major diversion, suggested by Idaho Mining Company personnel, would direct water from the upper Bucktail Creek drainage down through a bore hole to the 6850 level and out of the mine. If this diversion could also include discharge from upper Bucktail Creek, the majority of all water quality problems in the Bucktail Creek drainage could be eliminated. Such a diversion would necessitate enlarging the drainage system on the 6850 level, as a maximum flow of about two cfs should be expected at the 6850 portal during peak runoff periods. The diversion site on Bucktail Creek should be carefully selected so that all poor-quality water discharging to Bucktail Creek is included. The original plan called for completing a

borehole from the 7117 to the 6850 level, but this would not allow for diversion of poor-quality water from the creek. Analysis of the data show that poor-quality ground water enters Bucktail Creek below the 7117 waste pile, from 7000 to 6975 feet elevation. This poor-quality ground water might be diverted at higher elevations in the drainage. However, drill logs at DH6 show that the water table is about 35 feet below land surface in the 7265 waste pile. A similar depth to water probably exists at station 21 (7117 waste pile). It appears that completing a bore hole from an elevation of about 6975 feet in the Bucktail Creek streambed to the 6850 level would intercept all poor-quality water produced by upstream mining features, including portals and waste piles. This plan would have the drawback of diverting much good quality water during the spring runoff.

Surface Waste Features

Reclamation alternatives for surface waste features in the Blackbird Mining area are more expensive and difficult to initiate than underground reclamation alternatives. Surface waste features are vulnerable to flushing of oxidation products from both the pile surface and within the waste material. Erosion of the waste material by surface water is also a problem. Revegetation research is continuing on the F. S. and upper Blacktail Pit waste piles with encouraging results. This approach deals effectively with erosion and also helps to prevent leaching of acid salts from the waste pile. The development of a mature soil profile and establishment of vegetation elminates direct action of weathering processes on the waste material. Evapotranspiration losses from vegetation established on the waste pile will reduce the amount of water infiltrating into waste piles.

Therefore poor quality seeps and springs originating from waste piles should show a decrease in discharge. Additional reclamation procedures which may be applied to other surface waste features in the area are discussed in the following section.

7400 Waste Pile

Diversion of mine discharge from the 7400 level down the Brown Bear Shaft will eliminate the only source of acid recharge to the 7400 waste pile. Although the waste pile will continue to receive recharge in the form of spring snowmelt and rainfall, these sources of good-quality water should result in little metal production. Discharge from the 7400 portal now flows across the top and down the side of the waste pile, where erosion takes place continuously. Diversion of mine discharge down the Brown Bear Shaft will reduce erosion at this site. Revegetation should be initiated on this waste pile to further reduce erosion and to retard infiltration of water into the waste material.

Meadow Creek and 7100 Waste Pile

Eliminating discharge from the 7400 portal will eliminate a major source of acid contribution to the upper Meadow Creek drainage and to the 7100 waste pile. Some improvement in ground-water and surface-water quality in Meadow Creek could be expected as a result of this reclamation plan. However, streamflow will still recharge the 7100 waste pile and poor-quality water would continue to discharge at station 10, and erosion will continue as Meadow Creek flows over the edge of the waste pile. A diversion system might be installed along the waste pile to alleviate recharge and erosional problems. This diversion system could be either a culvert or an open canal which should begin at least 200 feet upstream

of the 7100 portal and continue to at least 200 feet downstream of the portal. The diversion channel should be constructed at a constant slope with the outfall at the same elevation as the stream channel below the waste pile. This construction procedure would minimize sediment build-up in the diversion structure. The diversion should be designed to carry discharge from at least a 25-year frequency runoff event.

West Fork Tailings Pile

Field research has shown that surface discharge of acid drainage is limited to small springs at the downstream face of the tailings pile. Ground water underflow probably contributes additional acid drainage to the West Fork of Blackbird Creek. Neither of these two sources of acid discharge represents a major water quality problem. Treatment of poor-quality ground water from the tailings pile would require the installation of a cutoff wall installed to bedrock to prevent ground water from flowing out of the area.

A potentially serious water quality problem is the existence of several barrels of cyanide buried in the east end of the tailings pile. Corrosion of the barrels will release the contents and infiltrating snowmelt will carry the cyanide down into ground water flow systems. This material should be exhumed and disposed of properly.

Another potentially serious problem is the concrete culvert which carries the West Fork of Blackbird Creek under the tailings pile. The culvert has proven adequate thus far to carry discharge from the West Fork. The intake to the culvert must be maintained constantly during the spring runoff period to prevent clogging by trash and sediment. If this intake were to become clogged, the stream would pond up behind the tailings pile.

A spillway was not included in the design of the pile and water flowing over the tailings pile could easily erode the tailings material. A major failure of the tailings pile could then follow.

Wind movement of fine grained material from the tailings pile constitutes a major form of erosion during dry summer months. Revegetation of the tailings pile surface may not be practical since future mining plans call for remilling this material to recover cobalt and copper. A layer of talus rock, locally plentiful, could be placed on the tailings pile and would eliminate this source of erosion. Remilling of the tailings material would also remedy the problem of a tailings pile failure.

Stream Channel Restoration

Disposal of dredged mining debris near Blackbird Creek may result in increased metal production. Future channel restoration should include plans to store mining debris at a site where contact with water can be avoided. The dredged material could be covered with topsoil and revegetated and the disposal area should be located so that leached metals will not be transported from the debris to ground-water flow systems. The West Fork tailings pile would satisfy these requirements.

Roads and Surface Exploration Features

During the course of exploration work, an extensive network of roads, trenches, and drill pads was constructed along the ridge bordering Meadow Creek on the east. The Idaho Mining Company graded in all exploration trenches along the ridge during the 1975 field season. This work should result in decreased recharge to fault and fracture zones on which the trenches were usually located. Surface runoff from disturbed areas will still be

higher than from similar areas covered with natural vegetation. Studies by the Forest Service (1959, p. 247) show that forested watersheds which have been 100 percent burned yield up to 20 percent more runoff than similar forested watersheds. Similar runoff increases can be expected from areas adjacent to Meadow Creek where exploration and road building has removed all vegetation. Grading and revegetation plans should be implemented for all these disturbed areas. Unlike surface waste features in the mining area, these areas are not contaminated by sulfide minerals and revegetation could be easily accomplished. Only those roads providing access to active mining areas should be maintained. All other roads, drill pads, and trenches should be revegetated. This work will reduce erosion and stream siltation in the mining area and control runoff from thunderstorms. Thunderstorm activity during summer months often results in flash flooding conditions which does much damage in disturbed mining areas.

Permanent access and haul roads should be built and maintained in accordance with recommended procedure. Sceva (1973) presents mine road construction guidelines modified from the Federal Water Pollution Control Administration report "Industrial Waste Guide - Logging Practices, 1970". These guidelines deal with the location, design, construction, and maintenance of mine roads. Air photos can also be used to locate areas where erosional and flooding problems are likely. Air photos taken during the spring snowmelt period of 1974 indicated that certain points along the main haul road are susceptible to erosion from surface runoff. During the succeeding field seasons it was noted that these same points suffered continued erosion during the spring runoff. Culverts capable of carrying runoff from spring snowmelt should be installed at these points.

Similar areas of annual erosion on the Blacktail Pit waste piles were noted on the air photos. Conversations with mining company personnel indicate that revegetation areas on these waste piles were destroyed by

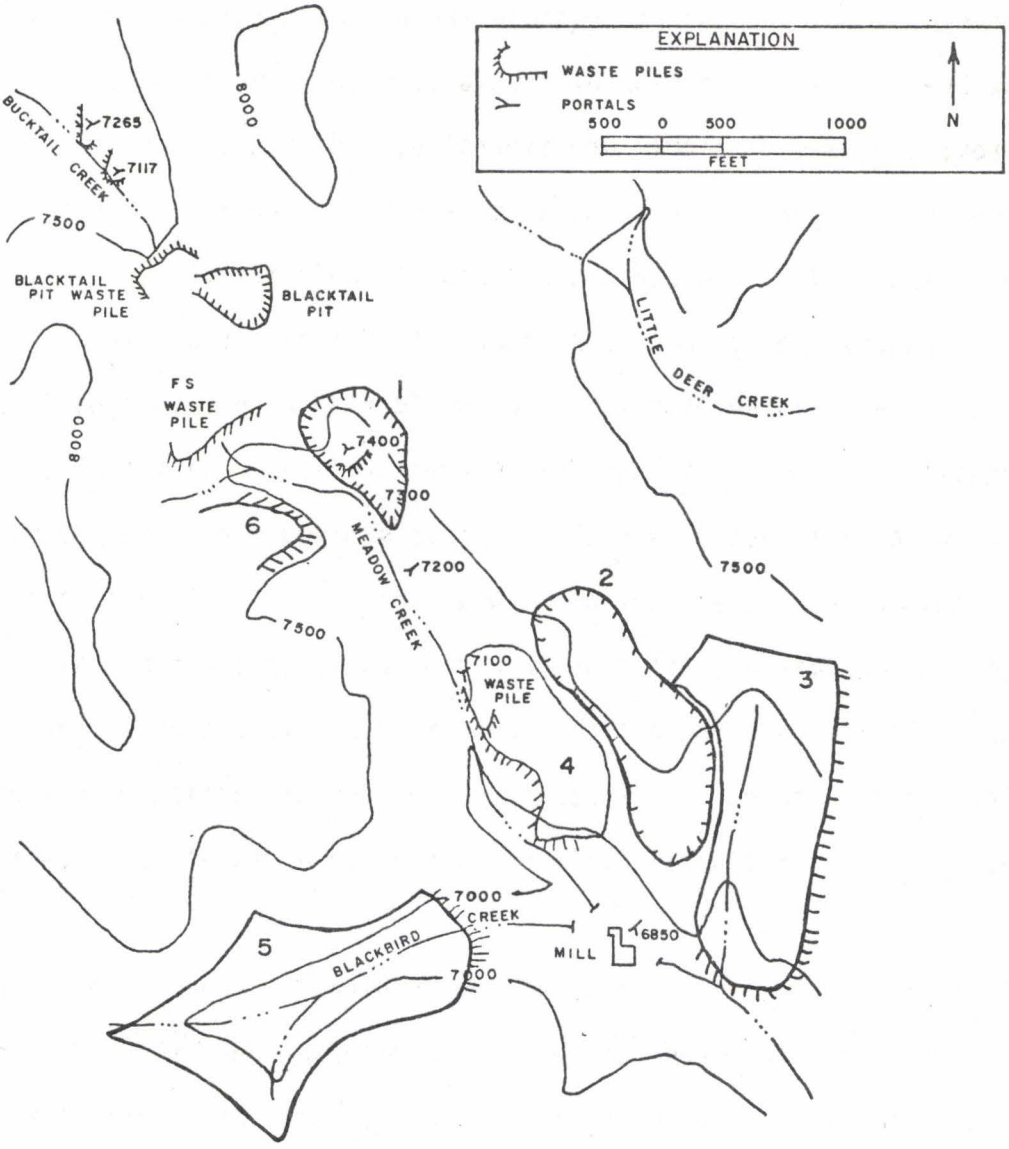
thunderstorm runoff during July, 1977. This type of destruction can be avoided by studying air photos and identifying paths that surface runoff is most likely to follow. Reclamation work can be initiated to prevent erosion and flooding from future runoff events.

Considerations for Future Mining Development

The Blackbird Mining area contains one of the largest developed cobalt deposits in the United States. Mining of the deposit will resume when economic conditions become favorable. Water quality problems associated with future mining activities can be minimized by applying reclamation procedures listed in the previous section and by considering the following points.

Hydrologic site selection factors should be considered for the location of tailings disposal areas, waste rock storage areas, and low grade ore storage areas planned for future mining activities. Disposal areas for tailings and waste rock are limited by the physical characteristics of the Meadow Creek and Blackbird Creek valleys. These valleys would normally be considered marginal for the disposal of the solid wastes since both have perennial streams and associated ground water flow systems, but these are no alternative sites in the Blackbird Mining Area.

Plans call for two new open pit mines, two stripping rock disposal areas, a low-grade ore disposal area, and a tailings disposal area (Davis, 1972). The tailings disposal area will be located on Blackbird Creek about 500 feet upstream of its confluence with Meadow Creek (Figure V-1). About 2 million cubic yards of tailings will be deposited behind a dam built from about 800,000 cubic yards of stripping rock from the proposed Idaho-Dandy open pit mine. Water from Blackbird Creek is to be diverted around the tailings pile



Proposed Mine Developement
1. Brown Bear Pit
2. Idaho-Dandy Pit
3. Idaho-Dandy stripping disposal area
4. Contingency stripping disposal area
5. Tailings disposal area
6. Contingency low grade ore disposal area

Figure V-1. Blackbird Mine facilities showing location of future mine developement.

in a channel. In view of the discharge differences between Blackbird and Meadow Creeks (stations 6 and 10A: 3,600 acre-feet vs. 400 acre-feet for the 1971 water year), it may be wise to relocate the proposed tailings pile in the Meadow Creek valley. Diversion of Blackbird Creek around the tailings pile may prove to be very difficult and expensive, and maintenance of this diversion channel after mining stops would also be expensive. Contamination of good-quality water in Blackbird Creek would be difficult to avoid during the construction, operation, and abandonment of a tailings pile of this size. Much smaller quantities of water would have to be diverted if the tailings pile was located in the Meadow Creek valley. Quantities of contaminated water associated with the tailings dam would also be much smaller. Assuming that a water treatment plant would be an integral part of the future mining facilities, the plant could be built to treat a smaller quantity of water. Objections to relocating the tailings pile are a lack of space and interference with haulage roads from the open pit areas. The Spring Creek valley above station 12 might be considered as an alternative tailings disposal area.

Figure V-1 shows that a major stripping disposal area is to be located in the gulch immediately east of the proposed Idaho-Dandy pit. This disposal site has potential water quality problems associated with it because of intermittent discharge during spring runoff. The total runoff from this gulch is small, on the order of 20 acre-feet per year. Placement of the stripping material may increase runoff from the gulch since evapotranspiration losses will decrease. Runoff from the gulch could be diverted to the water treatment plant; however, discharge from this waste feature may not require treatment if the stripping rock does not contain high amounts of sulfide minerals.

Discharge from underground workings can be expected to increase following the resumption of mining activities. Water for diamond drilling, sand-fill water, and recharge from the Idaho-Dandy open pit will constitute the majority of this increase. Recharge to mine workings from Meadow Creek should decrease with the development of the Brown Bear open pit. Discharge from Meadow Creek will enter the Brown Bear pit and continuous pumping of the pit will be required. Plans call for backfilling mined areas with sand fill from the mill. It is suggested that those workings nearest the surface, both existing and proposed, be sand filled to discourage the entrance of recharge to mine workings. Sand filling will reduce subsidence problems and prevent the development of fracture systems associated with subsidence. Numerous bulkheads have collapsed in the existing workings allowing sand fill to escape from mined out areas. Bulkheads installed for future sand fill operations should be fully reinforced to prevent collapse.

The total volume of acid water presently discharging is small in relation to total discharge from the mining area. Some poor-quality water is to be expected from the proposed mining area. Treatment costs will be considerably less if this discharge is isolated from good-quality water. Ground water discharge from all surface waste features should be intercepted by the use of cutoff walls and this discharge should be diverted to the water treatment plant.

Reclamation Costs

Reclamation plans for two molybdenum mines in central Colorado were studied to get an estimate of the costs of the various reclamation alternatives suggested for the Blackbird Mine. These mines are the Urad Mine near Empire, Colorado, and the Climax Mine located near Leadville, Colorado. Both mines are situated in areas similar to the Blackbird Mining District,

and both mines use mining techniques similar to those employed at the Blackbird Mine. The Continental Divide crosses the Climax property, and the mill facilities are located at an elevation of 11,318 feet above sea level. Underground panel caving and open pit mining is used to remove from 37,000 to 40,000 tons of molybdenite ore per day from a deposit located in Bartlett Mountain and Ceresco Ridge. It is estimated that at least 450 million tons of ore remain to be mined as of 1974 (Achttien, 1974).

A total of about 14 million tons of molybdenite ore was removed from the Urad Mine before the Urad ore body was depleted in 1974. A modified block-caving system of underground mining was used to remove the ore. The mill facilities were located at an elevation of about 10,200 feet above sea level. Climate of both mines is very similar. An average of 24.6 inches of precipitation over an 11 year period was recorded at the Jones Pass Weather Station near the Urad Mine. Most of the precipitation is in the form of snow. Tailings and mine waste deposition areas exist at both mines (Wright and Brown, 1974).

The following descriptions of selected reclamation procedures and cost estimates are taken from an outline of plans and techniques to be used at the Urad Mine (Wright and Brown, 1974). The outline was filed with the Colorado Department of Natural Resources in 1974 in response to Colorado mining laws of 1969 and 1973. An inflationary increase of eight percent for 1975 and seven percent for 1976-79 was used to arrive at the estimates. The estimates given are for 1976. These reclamation costs should be representative of costs which will be encountered in restoration work in the Blackbird Mining Area. The tailings area reclamation sequence at the Urad Mine consisted of the following steps: (1) landscape with rock, (2) spread wood chips, sewage sludge and P_2O_5 amendments, (3) mix the amendments into the

fragmented rock with a dozer, (4) spread topsoil on selected difficult areas, (5) seed with grass mixture, (6) spread as many logs from the dead timber clean-up operation as are readily available, (7) plant trees (containerized and transplanted seedlings), (8) irrigate as much as feasible and necessary for the first season, and (9) follow with more trees and shrubs. The 1977 cost estimate for this procedure was about $2,500 per acre. The sewage sludge was to be hauled from Denver and an initial application of 20 tons/acre was suggested for the tailings pile. Such large amounts of sewage sludge are not available from cities in the vicinity of the Blackbird Mine and this soil amendment would probably be omitted from the reclamation sequence as applied to the West Fork Tailings Pile. This would reduce the reclamation cost per acre for the tailings pile.

Mine waste reclamation at the Urad Mine presented a difficult problem due to very steep stopes and southern aspects. Scarification of the slopes followed by establishment of grass seedlings held in place by some type of mesh was proposed. Trees were to be planted on the dump. Cost of this work was estimated to be about $2,100 per acre. If this reclamation procedure were applied to waste piles at the Blackbird Mine, it is suggested that a series of benches, similar to those seen in highway cuts around the state, be established down the face of the waste pile. These benches would provide flat areas for vegetative growth and would provide catchment areas for moisture.

Some 10 miles of mine roads were to be reclaimed in the mining area. This reclamation work consisted of closing and revegetating the roads. The cut and fill areas were to have been hydromulched and road beds scarified and seeded. This work was estimated to cost about $400 per

acre. Hydromulching of any additional disturbed areas was estimated to cost $270 per acre. Hydromulching was proposed for areas such as road and pipeline cuts and fills and other areas that were inaccessible for other methods of planting.

Treatment costs for acid discharge from abandoned mines in the area were not discussed either reclamation outline. The reclamation outline for the Climax Mine did point out that Climax had acquired abandoned mines during expansion periods and that acid discharge from these abandoned mines was diverted into the Climax closed industrial water circuit. It is not known whether this is intended as a permanent solution to acid mine discharge.

Reclamation costs discussed in the preceding paragraphs could be decreased if the design of a new mining operation included comprehensive reclamation measures which would accompany the mining process. However, the ultimate goal of the reclamation plan should be the design of a mining operation where continued water treatment is not required after closure of the mine. Continued water treatment is usually needed for acid discharge from underground workings. Sealing or flooding of underground workings has been proposed as a method of preventing acid discharge. These methods may work reasonably well for flat lying strata in areas of low relief but would be of little use for steeply dipping strata and rugged terrian such as the Blackbird Mining District. Additional research is needed in this area of mine reclamation.

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Appendix I-1. Water quality analysis of samples collected July, 1967 in the Panther Creek Drainage Study Area (ppm). Numbers in parenthesis are corresponding University of Idaho sampling stations. Forest Service Data.

Station	Fe	As	Ca
1M (10A)	25.0	Neg.	7.50
2M (13)	2.0	Neg.	15.90
3M (16)	0.0	Neg.	1.05
1B (8)	0.0	Neg.	5.55
2B (6)	50.0	0.2	11.60
3B (3)	0.0	Neg.	4.05
4B (2)	2.0	Neg.	6.30
5B	15.0	Trace	10.50
6B	1.5, 1.4	Neg.	7.00
7B	.1, .63	Neg.	6.05
8B	0.0	Neg.	1.95
9B	0.0	Neg.	7.05
10B (7)	290.0	0.4	10.50
11B	20.0	Neg.	5.70
1P	.76		
2P	.23		
3P	1.55		
5P	1.34		
6P	.41		
7P	1.58		
8P	1.49		
9P	3.32		

Appendix I-2. Water quality analysis of samples collected October 19, 1967, in the Panther Creek Drainage Study Area in ppm. (Except pH). Numbers in parenthesis are corresponding University of Idaho sampling stations. Forest Service data.

Test	Station 1B (8)	2B (6)	4B (2)	5B	6B	8P	9P	1P
pH	7.00	3.40	5.30	3.70	6.50	7.50	7.40	7.30
Total Solids	46.00	504.00	116.00	252.00	70.00	70.00	56.00	58.00
Alk.	85.00	100.00	70.00	70.00	60.00	150.00	175.00	85.00
Hardness	70.00	250.00	80.00	120.00	90.00	90.00	120.00	90.00
Ca	18.00	51.00	20.00	28.00	20.00	24.00	32.00	24.00
Mg	6.00	29.00	7.00	12.00	16.00	7.00	10.00	7.00
Fe	0.60	2.85	2.40	3.12	1.20	0.37	0.05	0.07
SO_4	11.00	224.00	90.00	104.00	28.00	17.00	41.00	68.00
NO_3	1.04	2.50	0.50	1.90	1.14	0.88	1.06	1.04
PO_4	0.12	0.16	0.10	0.32	0.11	0.16	1.88	0.16
CI	9.00	32.00	19.00	17.00	6.00	6.00	9.00	6.00
Mn	0.05	0.50	0.50	0.60	0.80	0.05	0.05	0.05
F	0.06	0.00	0.16	0.13	0.18	0.51	0.63	0.25
Na	6.00	20.00	11.00	10.00	4.00	3.00	6.00	4.00

Appendix I-3. Dissolved copper content of water samples collected in the Panther Creek drainage study area, 1967. Concentrations are in micrograms per liter. Numbers in parenthesis are corresponding University of Idaho sampling stations. Forest Service data.

Station	3-06	5-04	6-06	6-13	6-26	7-15	9-22	10-3	10-25
1B (8)	-----		-------	0	---	500		75	0
2B (6)	3,000	13,500	2,000	2,000	---	7,000		16,000	11,250
3B	-----	0	0	0	---	0		0	0
4B	2,000	3,200	0	50	---	0	0	75	0
5B	-----	2,250	300	1,000	---	200	1,700	7,000	1,950
6B	-----	500	0	200	96	0		750	200
7B	-----	------	0	50	15	0	0	50	0
8B	-----	------	0	100	---	0		0	------
9B	-----	------	-------	0	---	0		150	------
10B	-----	------	138,000	92,000	---	20,000	5,300	7,000	5,000
11B	-----	------	8,800	9,000	---	14,000		22,500	20,250
1M	-----	------	-------	------	---	18,000	12,400	40,050	------
2M	-----	------	-------	------	---	2,000		14,950	3,500
3M	-----	------	-------	------	---	0		150	0
1P	-----	------	-------	------	7	------	------	------	0
2P	-----	------	-------	------	14	------	------	------	0
3P	-----	------	-------	------	56	------	------	------	150
4P	-----	------	-------	------	52	------		------	100
5P	-----	------	-------	------	---	------		------	0
6P	-----	------	-------	------	175	------		------	100
7P	-----	------	-------	------	68	------		------	100
8P	-----	------	-------	------	55	------		------	50
9P	-----	------	-------	------	6	------		------	0

Appendix I-4. Content of heavy metal ions found in water samples collected in the Panther Creek drainage study area in micrograms per liter. Samples collected 10/2/67, 12/8/67, 1/11/68 and 3/15/68. Forest Service data.

Station	Metal							
	Fe	Mn	Cu	Co	Zn	Cr	As	Ni
1P	190	4	20	9	-	-	5	-
2P	40	1	5	1	8	3	5	10
	24	1	35	-	-	-	5	-
7B	190	3	5	5	9	2	5	10
	110	2	13	-	19	-	-	-
	92	4	5	-	-	6	8	10
6B	1560	90	270	560	15	2	5	30
	2000	115	270	-	20	6	47	30
	2000	114	190	-	20	6	-	20
	960	-	230	-	-	-	-	-
3P	1560	90	240	481	13	2	24	20
	1190	99	160	-	15	6	24	20
	1150	92	130	-	25	6	-	-
	1300	-	170	-	-	-	-	-
4P	1000	41	140	280	16	2	22	20
	490	67	50	-	12	6	18	20
	1000	58	86	-	60	6	-	-
	1090	-	98	-	-	-	-	-
5P	90	2	10	44	12	6	4	10
	57	2	8	-	12	6	-	10
	16	1	10	-	99	12	-	-
	240	-	28	-	-	-	-	-
6P	38	13	150	184	9	3	12	10
	78	6	50	-	21	6	5	10
	78	3	52	-	30	6	-	10
	37	-	35	-	-	-	-	-
7P	1130	34	140	263	9	2	23	10
	500	59	50	-	17	6	19	-
	890	41	86	-	46	6	-	-
	800	-	84	-	-	-	-	-
8P	690	20	90	184	14	3	31	20
	2060	39	50	-	19	6	50	10
	610	28	77	-	15	6	-	20
	560	-	56	-	-	-	-	-
9P	310	18	3	-	1	3	10	10
	110	8	6	-	12	6	5	10
	130	-	2	-	-	-	-	-
	-	-	-	-	-	-	-	-

Appendix II-1. Water quality and quantity data for 1969 from the Blackbird Mining Area. Samples collected by the Idaho Mining Company.

STATION 7 (685 PORTAL)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
22469		3.0	17.2	3.2	39.8
22569	13.3	3.1	18.8	6.3	42.0
22669		3.0	13.6	2.0	21.5
22769	30.	2.95	18.0	5.9	40.5
22869		3.12	15.1	2.4	30.8
30369		3.23	12.5	2.3	28.0
30469		3.05	10.7	7.5	19.5
30569	24.	3.15	19.0	1.9	45.4
30769		3.23			41.8
31069		3.13	17.5	4.2	59.4
31269	30.	2.90	19.3	5.5	47.5
31369	30.	2.88	20.9	6.9	48.8
31469	30.	2.92	19.8	6.6	51.4
31769		2.91	19.6	8.4	52.9
31869	30.	2.97	19.1	7.6	54.4
31969	30.	2.83	19.0	7.4	45.6
32069	30.0	2.80	18.1	5.9	46.1
32169	30.0	2.8	18.0	6.8	45.0
32469	30.	2.82	18.2	5.7	50.0
32569	30.	2.85	18.0	6.4	50.3
32669	30.	3.17	19.9	6.5	53.1
32769	30.	2.73	20.9	39.5	37.4
32869	30.	2.82	22.6	53.3	34.5
33169	30.	2.92	23.2	59.8	38.2
40169	40.	2.91	22.2	51.6	43.1
40269	40.	2.90	22.7	50.6	43.3
40369	40.	3.08	23.2	46.3	32.7
40769	30.	2.99	31.0	67.1	76.3
40869	40.	2.95	28.5	74.3	74.3
40969	40.	2.88	27.0	66.7	70.2
41469	40.	3.02	32.9	80.8	78.0
41569	40.	3.02	32.0	72.8	76.8
41769	40.	3.02	30.6	56.5	71.5
41869	60.	2.98	32.5	65.2	72.2
42169	60.	3.08	32.8	63.0	75.7
42269	60.	3.15	34.5	72.0	75.5
42369	60.	3.02	36.9	83.7	78.2
42469	60.	3.12	37.9	79.3	77.3
42569	50.	3.16	37.0	73.0	75.5
42869	60.	3.02	35.1	60.7	73.3
42969	40.	3.15	34.3	61.4	75.6
43069	40.0	3.05	36.2	60.7	71.8
50169	40.0	3.04	35.4	57.9	71.0
50269	60.0	3.05	35.0	54.1	70.2
50569	40.0	3.26	34.4	54.0	73.6
50669	60.0	3.10	33.1	57.1	74.3
50769	40.0	3.02	34.2	62.1	74.7
50869	40.0	3.03	34.9	61.3	76.7
50969	40.	3.02	36.5	61.5	75.4

STATION 7 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
51269	60.	3.10	35.0	58.3	75.8
51369	60.	3.23	35.0	56.9	76.3
51569	60.	3.14	35.2	51.5	78.2
51669		3.12	34.7	48.4	77.8
51969		3.10	35.5	44.4	77.9
52069		3.12	42.8	66.6	77.0
52169		3.18	43.8	49.2	77.1
52269		3.25	43.6	48.3	77.2
52369		3.25	42.9	46.9	77.5
52669	40.	3.10	42.1	42.7	23.5
52769	80.	3.08	42.1	41.0	11.4
52869		3.19	40.4	38.5	16.0
52969	100.0	3.23	39.7	37.7	18.5
60269	100.	3.50	38.8	34.0	75.9
60369	100.0	2.99	40.9	31.7	78.5
60469	100.	3.07	40.8	31.0	78.2
60669		3.08	40.6	29.8	78.5
60969		3.05	38.9	26.2	78.1
61069		3.18	39.5	26.1	77.5
61169	80.	3.00	37.6	25.5	80.2
61269		3.00	36.8	25.0	74.9
61369		3.02	36.3	24.2	80.0
61669		3.25	35.1	22.8	80.2
61769		3.11	37.2	24.2	80.9
61869		3.32	36.5	22.5	80.0
61969		3.28	35.6	21.1	80.4
62069		3.18	36.4	20.2	78.0
62369	30.	3.25	35.6	18.7	78.0
62469	30.	3.32	36.4	18.5	77.8
62569	40.	3.52	35.2	18.4	78.2
62669		3.35	36.0	17.5	80.4
62769		3.27	35.4	16.8	79.5
63069	40.	3.30	35.4	15.9	79.5
70169	40.0	3.38	34.9	17.3	80.0
70269	40.0	3.35	34.9	16.2	79.5
70369		3.32	34.8	15.7	80.2
70769	40.0	3.43	48.2	90.9	85.6
70869	40.0	3.23	34.0	20.2	11.5
70969	40.0	3.25	34.3	16.7	11.0
71069	40.0	3.29	33.9	15.5	14.9
71169	40.0	3.40	33.2	14.4	18.8
71469	40.0	3.26	35.4	15.0	78.8
71569	40.0	3.08	32.4	13.4	76.6
71669	40.0	3.07	32.1	13.4	76.4
71769	40.0	3.10	31.8	15.9	76.5
71869	40.0	3.18	32.4	16.1	76.9
72169	40.0	3.30	31.2	14.0	77.7
72269	40.0	3.05	33.0	14.9	78.1
72369	40.0	3.08	32.6	14.7	78.4

STATION 7 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
72469	40.0	3.11	31.9	14.5	78.1
72569	40.0	3.15	31.4	14.2	77.7
72869	40.0	3.17	33.4	12.3	78.3
72969	40.0	3.22	33.0	12.5	78.0
73069	40.0	3.20	32.1	12.2	78.4
73169	40.0	3.25	32.8	12.1	79.1
80169		3.30	32.4	11.8	78.9
80469	40.0	3.20	31.8	10.6	77.6
80569	40.0	3.24	31.3	10.2	78.1
80669	40.0	3.28	30.9	10.1	78.1
80769	30.0	3.12	31.2	10.0	78.6
80869	30.0	3.55	30.6	9.8	80.7
81169	40.0	3.16	32.3	12.0	79.6
81269	30	3.24	31.7	13.0	79.8
81369	30	3.27	31.5	13.3	79.6
81869	30	3.32	29.2	12.2	80.2
81969	30	3.00	29.5	10.7	75.5
82069	30.0	3.30	28.9	10.5	75.1
82169		3.02	28.7	10.5	75.3
82269	30.0	3.02	29.0	11.5	76.1
82569	30.0	3.22	28.5	10.8	78.0
82669	30.0	3.08	31.1	11.5	78.1

STATION 7 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
82769	30.0	3.15	29.6	10.8	77.0
82869	30.0	3.12	31.3	11.6	76.6
82969	30.0	3.08	31.0	12.0	76.2
90269	30.0	3.30	31.2	14.2	77.5
90369	30.0	3.02	30.5	13.5	79.0
90469	30.0	2.97	29.8	13.1	78.8
90569	30.0	3.03	30.0	12.5	78.6
90869	30.0	3.03	29.4	94.5	78.9
90969		3.05	29.4	94.2	79.0
91069	30.0	3.16	29.1	12.7	79.7
91169	30.0	3.12	28.9	12.5	79.2
92269	30.0	3.07	16.9	11.4	78.1
92369	30.0	3.12	16.6	9.9	77.6
92469		3.12	17.1	11.0	77.8
92569	30.0	3.16	10.0	10.9	77.5
92669	30.0	3.17	19.2	11.0	77.6
92969	30.0	3.11	16.1	10.9	78.0
93069	30.0	3.15	16.3	11.2	77.0
100169	30.0	3.19	16.7	11.2	
100269			16.5	11.4	75.6
100369		3.18	16.6	11.2	75.6

STATION 9 (ST JOE PORTAL)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
71669	4.8				
71769	4.8	3.22	63.2	76.4	72.1
71869	4.8	3.30	62.6	75.3	73.9
72169	4.8	3.42	63.2	75.7	76.8
72269	4.3	3.18	63.7	78.2	74.6
72369	3.4	3.18	62.8	77.3	75.3
72469	4.0	3.22	62.0	76.9	76.2
72569	3.4	3.30	61.4	77.0	77.7
72369	3.4	3.28	67.7	76.9	75.8
72969	3.4	3.35	67.6	77.1	77.2
73069	3.4	3.32	66.2	77.2	78.0
73169	3.4	3.38	67.8	76.9	78.4
80169		3.44	68.4	76.5	79.3
80469	3.2	3.32	66.8	75.2	78.1
80569	3.4	3.37	66.8	74.6	78.6
80669		3.45	66.2	74.5	79.3
80769	3.2	3.31	66.2	74.0	79.6
80869		3.58	65.8	74.2	81.0
81169	3.4	3.30	68.9	77.7	77.6
81269	3.0	3.30	68.0	77.0	78.7

STATION 9 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
81369	3.0	3.33	66.3	76.8	73.7
81869		3.43	66.3	76.6	81.6
81969	1.7	3.11	64.0	75.3	75.1
82069	1.5	3.15	62.5	73.5	75.8
82169	1.5	3.20	61.5	73.5	76.7
82269	1.5	3.25	61.0	73.4	77.0
82569	1.3	3.39	60.4	73.3	77.9
82669	1.3	3.21	65.1	73.3	74.8
82769	1.3	3.30	64.3	73.0	71.2
82869	1.3	3.29	63.8	74.4	71.8
82969	1.3	3.20	64.5	72.3	72.9
90269	1.5	3.50	63.6	70.8	76.3
90369	1.0	3.16	62.5	71.8	72.2
90469	1.0	3.08	62.0	70.5	72.6
90569		3.18	62.0	70.4	73.0
90869	1.0	3.23	61.3	41.2	76.3
90969		3.25	60.9	40.8	77.3
91069	0.8	3.36	60.7	68.9	78.3
91169		3.52	59.8	66.4	79.0

STATION 10A (MEADOW CREEK)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
22669	15.0	3.25	31.5	22.6	23.1
22769	15.0	3.3	31.8	31.4	15.6
22869	15.0	3.22	31.8	31.7	24.4
30369	15.0	3.5	31.1	30.8	31.5
30469	15.0	3.3	39.6	30.0	
30569	15.0	3.48	29.7		22.9
30769	15.0	3.47	29.3	29.6	35.9
31069	15.0	3.52	29.4	32.8	31.4
31269	12.0	3.25	29.9	31.8	10.7
31369	13.3	3.32	30.2	31.7	17.2
31469	15.0	3.32	29.8	31.6	19.0
31769	30.	3.38	25.4	37.5	15.2
31869	17.1	3.38	27.2	30.0	21.4
31969	17.1	3.37	27.0	29.8	26.6
32069	17.1	3.20	27.1	29.9	7.9
32169	17.1	3.19	26.9	30.8	6.7
32469	30.	3.20	35.1	39.2	26.6
32569		3.30	35.5	40.4	27.2
32669	24.	3.50	37.5	42.2	38.7
32769	60.	2.78	60.8	79.8	50.5
32869	60.	2.85	59.8	79.2	55.7
33169	120.	2.99	51.7	75.4	40.2
40169		3.07	48.9	76.1	45.7
40269		3.12	46.7	74.0	43.8
40369		3.24	46.0	75.9	19.0
40769		3.25	48.4	75.9	31.4
40869		3.25	45.7	74.5	21.8
40969		3.21	51.0	78.0	24.3
41469		3.38	51.1	72.7	30.5
41569		3.32	52.1	28.9	35.3
42169		3.40	46.6	70.1	36.2
42269		3.53	44.8	64.7	20.3
42369		3.50	55.9	60.6	12.1
42469		3.55	37.7	65.0	13.3
42569	167.	3.60	34.9	61.8	11.9
42869	150.	3.43	39.1	64.5	27.8
42969	150.	3.58	37.9	65.3	37.6
43069	100.	3.47	39.8	67.5	15.9
50169	150.	3.42	41.9	68.3	18.3
50269	150.	3.41	43.6	69.8	22.0
50569	150.	3.62	43.1	69.3	43.8
50669	150.	3.48	36.8	65.7	14.3
50769	150.	3.50	31.7	63.1	9.3
50869	150.	3.50	31.1	62.2	
50969	150.	3.57	28.0	60.4	8.0
51269	300.	3.68	25.8	56.5	15.5
51369	300.	3.88	28.7	53.8	24.2
51569		3.76	20.3	42.8	3.8
51669		3.90	15.0	34.0	3.0

STATION 10A CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
52069		4.15	9.2	22.6	
52169		4.30	9.7	26.3	
52269		4.30	10.9	22.8	2.3
52369		4.18		27.1	5.8
52669		3.93	11.9	22.2	0.4
52769		4.10	9.4	22.2	0.3
52869		3.90	13.0	24.9	0.5
52969		3.90	14.1	26.8	0.8
60269		4.10	16.2	29.0	17.6
60369		3.68	17.1	27.2	2.5
60469		3.20	18.3	28.5	2.6
60669		3.80	17.5	26.0	2.5
60969		3.85	19.1	30.0	6.3
61069		3.88	19.1	28.2	16.1
61169		3.63	19.1	28.9	4.5
61269		3.60	19.2	28.4	4.4
61369		3.70	19.6	29.2	9.2
61669		3.88	20.1	25.5	27.5
61769		3.80	20.6	25.4	19.6
61869		3.45	19.5	34.3	37.9
61969		3.95	20.3	23.8	35.2
62069		3.66	20.9	22.0	13.8
62369		3.88	19.7	23.1	18.0
62469		3.98	20.0	23.4	36.6
62569		4.18	21.2	23.4	35.2
62669		3.88	20.0	22.1	7.4
62769		3.40	62.9	71.8	60.0
63069		3.47		72.3	63.4
70169		3.50	63.4	68.3	66.8
70269		3.48	63.9	78.0	66.5
70369		3.03	63.8	73.6	78.9
70769		3.63	57.8	68.6	67.1
70869		3.40	63.8	72.7	0.7
70969		3.40	66.0	77.6	1.1
71069		3.50	64.7	75.5	1.4
71169		3.46	64.6	75.4	1.4
71469		3.45	66.4	78.6	2.6
71569		3.20	64.5	75.9	67.6
92269	50.0	3.18	45.1	68.4	73.5
92369	42.8	3.19	44.1	68.0	73.2
92469		3.22	45.8	68.5	
92569	50.0	3.03	45.2	68.5	74.5
92669	50.0	3.28	45.6	68.8	75.6
92969	50.0	3.20	40.6	74.4	73.3
93069	50.0	3.21	40.0	73.8	72.4
100169		3.25	40.1	73.5	72.1
100269		3.27	40.9	74.3	72.0
100369		3.29	40.0	73.1	71.5

STATION 15 (7400 PORTAL)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
22469	2.2	3.1	24.2	10.2	12.3
22569	2.5	3.3	24.5	10.3	12.1
22669	2.3	3.1	24.4	10.4	13.0
22769	2.9	3.2	24.3	9.8	10.1
22869	2.7	3.35	24.9	10.1	14.3
30369	2.7	3.20	22.8	10.3	41.7
30469	2.6	3.28	23.7	9.4	29.7
30569	2.7	3.3	44.2	10.1	23.1
30769	2.6	3.3	24.0	9.7	44.5
31069	2.7	3.32	22.8	10.7	38.0
31269	3.0	3.03	24.4	10.3	13.2
31369	2.7	3.07	24.2	10.2	12.0
31469	2.5	3.14	24.7	10.5	17.6
31769	2.6	3.12	23.6	10.7	22.7
31869	2.6	3.18	23.8	10.6	29.8
31969	2.6	3.22	22.7	9.8	39.3
32069	2.6	2.88	22.7	9.3	10.8
32169	2.7	3.00	22.4	9.7	9.7
32469	2.7	3.12	22.3	7.0	15.2
32569	2.6	3.14	22.1	9.0	19.8
32669	2.5	3.28	22.2	8.4	28.8
32769	2.7	2.91	22.2	8.8	7.7
32869	2.7	3.00	21.7	8.7	6.3
33169	5.0	3.05	57.2	92.3	34.2
40169	5.0	3.02	53.0	91.2	40.4
40269	5.0	3.00	55.1	91.4	96.9
40369	7.5	3.06	58.7	97.1	28.4
40769	5.4	3.08	59.0	96.9	54.4
40869	5.4	3.02	60.1	95.4	55.7
40969	7.5	3.04	59.8	97.0	55.3
41069	8.6	3.05	59.5	97.1	50.8
41469	10.0	3.10	64.5	97.0	75.0
41569	10.0	3.08	63.6	96.9	74.8
41769	12.	3.02	63.1	97.6	74.0
41869		3.08	67.2	98.0	73.9
42169	30.	3.12	70.5	98.7	78.6
42269	20.	3.23	71.4	94.0	74.6
42369	30.	3.18	77.3	95.2	72.4
42469	60.	3.19	77.8	95.2	73.8
42569	20.	3.18	76.3	96.2	76.6
42869	30.	3.05	75.5	94.5	79.4
42969	30.0	3.22	75.2	94.9	79.7
43069	30.	3.02	77.1	94.9	77.5
50169	30.	3.08	76.2	94.5	77.9
50269	20.	3.08	75.7	94.5	77.8
50569	24.	3.33	75.2	94.5	78.6
50669	30.0	3.12	70.7	95.2	78.0
50769	40.0	3.05	70.6	95.2	77.4
50869	40.0	3.08	72.0	95.1	77.2
50969	40.	3.12	69.6	95.0	77.4

STATION 15 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
51269	24.0	3.18	69.9	94.1	79.3
51369	20.0	3.40	68.5	94.3	79.7
51569	18.5	3.12	70.3	94.9	79.7
51669		3.20	69.9	94.4	80.0
52069		3.16	72.8	94.7	78.2
52169		3.19	77.7	94.6	78.1
52269		3.33	72.2	94.2	78.3
52369		3.42	71.8	94.3	78.9
52669	133.3	3.17	68.9	94.5	96.4
52769	40	3.18	68.9	94.3	1.6
52869		3.22	68.5	94.4	1.4
52969	133.3	3.27	68.0	94.5	2.4
60269	28.6	3.42	66.8	93.7	3.9
60369	25.0	2.98	72.0	92.8	77.1
60469	28.6	3.04	71.0	92.4	77.0
60669		3.03	71.4	92.1	76.1
60969		3.08	69.1	91.8	77.3
61069		3.23	68.8	90.1	76.5
61169	4.0	3.01	68.1	91.6	78.1
61269		3.07	65.1	91.2	78.5
61369		3.12	63.9	90.4	78.1
61669		3.28	62.5	88.4	79.0
61769		3.18	64.9	87.0	79.7
61869		3.34	63.5	86.2	79.3
61969		3.32	62.5		78.6
62069		3.20	63.2	83.5	74.0
62369	17.1	3.30	61.6	81.4	75.2
62469	17.1	3.35	60.8	81.4	73.5
62569	10.0	3.80	60.5	59.9	78.2
62669	8.6	3.30	61.8	79.3	73.8
62769		3.29	61.0	78.4	72.7
63069	10.0	3.30	59.7	75.9	71.5
70169	12.0	3.38	59.1	75.8	78.6
70269	12.0	3.40	59.7	75.5	71.7
70369		3.42	58.8	74.3	73.4
70769	8.6	3.52	56.7	71.5	77.0
70869	6.0	3.22	57.4	72.1	69.5
70969	6.0	3.30	57.2	70.8	62.8
71069	6.0	3.35	56.8	70.7	66.4
71169	6.0	3.32	56.5	71.4	66.0
71469	6.0	3.26	58.0	72.2	74.6
71569	6.0	3.12	55.3	69.5	66.8
71669	6.0	3.20	54.2	69.0	66.4
71769	6.0	3.25	53.6	68.5	67.6
71869	6.0	3.28	52.6	67.9	68.4
72169	6.0	3.40	51.4	65.0	71.5
72269	6.0	3.12	53.7	67.8	67.6
72369	6.0	3.22	52.3	66.3	68.0
72469	6.0	3.28	51.5	65.0	68.1
72569	6.0	3.38	50.7	64.7	69.5

STATION 15 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
72869	6.0	3.18	54.4	61.9	65.4
72969	6.0	3.28	53.7	62.4	66.7
73069	6.0	3.28	51.9	61.4	67.5
73169	6.0	3.30	53.8	59.9	66.6
80169		3.42	53.0	59.0	67.9
80469	4.2	3.23	51.8	56.3	66.5
80569	6.0	3.38	51.1	59.0	65.2
80669	6.0	3.38	50.3	54.6	66.5
80769		3.28	50.3	54.0	69.5
80869		3.40	49.8	53.4	74.4
81169	6.0	3.18	52.7	56.3	65.7
81269	6.0	3.35	51.5	55.6	63.3
81369	4.2	3.35	50.8	54.9	64.3
81869		3.32	48.6	52.8	70.2
81969	3.1	2.80	47.7	51.5	54.6
82069	4.0	3.12	46.2	50.0	57.5
82169	4.0	3.12	45.5	48.8	56.7
82269	4.0	3.20	44.7	48.2	57.4
82569	4.0	3.33	44.0	47.4	65.3
82669	4.0	3.22	48.1	49.0	58.4

STATION 15 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
82869	4.0	3.22	45.8	46.9	51.9
82969	4.0	3.28	46.3	45.9	52.3
90269	4.0	3.38	44.8	44.8	62.1
90369	4.0	3.18	44.0	44.8	51.1
90469	4.0	3.02	43.6	44.4	56.9
90569	4.0	3.04	43.0	43.6	51.6
90869	4.0	3.26	42.6	56.5	57.1
90969		3.24	43.2	55.9	58.4
91069	4.0	3.22	42.0	41.0	62.7
91169		3.32	41.5	39.7	67.0
92269	4.2	3.12	26.2	39.1	53.3
92369	4.2	3.26	25.5	37.6	52.7
92469		3.30	24.9	37.9	52.7
92569	4.2	3.32	25.5	37.7	54.3
92669	4.0	3.33	25.9	37.7	57.1
92969	4.0	3.19	23.9	40.5	57.0
93069	4.2	3.32	23.8	39.6	54.4
100169	4.0	3.37	23.7	38.7	53.3
100269		3.34	23.4	38.0	52.0
100369		3.39	23.9	38.5	

STATION 20 (7265 PORTAL)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
22469	1.6	2.9	57.7	33.0	68.0
22669	1.7	2.8	57.2	34.9	66.6
22769	1.5	2.8	55.0	29.2	69.4
22869	1.5	3.15	55.8	28.9	70.2
30369	1.4	3.08	54.8	38.8	72.8
30469	1.2	2.85	55.5		68.1
30569	1.4	3.07	54.9	38.2	67.6
31069	1.4	3.04	54.4	33.5	74.9
31269	1.4	2.77	60.5	32.8	74.9
31369	1.4	2.78	61.1	33.5	74.2
31469	1.5	2.80	61.1	33.9	74.5
40169	4.3	2.88	63.8	71.8	73.1
40269	5.0	2.89	63.9	92.0	74.2
40369		2.88	61.3	94.4	60.5
40769	3.9	3.22	39.9	84.4	45.5
40869	2.9	3.18	31.1	71.2	16.8
42869	10.0	3.13	75.4	93.6	79.3
42969	12.	3.28	74.3	93.6	79.4
43069	8.6	3.08	77.2	94.0	76.5
50169	9.2	3.07	76.2	93.6	76.0
50269	7.5	3.10	73.6	93.3	76.7
50569	6.6	3.35	76.3	93.0	77.7
50669	6.8	3.13	70.0	93.5	72.3
50769	6.6	3.06	70.3	93.5	77.4
50869	8.0	3.02	69.4	93.7	77.3
50969	7.5	3.08	69.6	93.8	78.4
51269	7.5	3.20	68.2	94.9	77.6
51369	8.7	3.40	70.1	94.2	80.6
51569	6.6	3.17	70.6	94.4	79.6
51669		3.20	70.7	94.2	80.2

STATION 20 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
52069		3.19	74.8	94.4	79.3
52169		3.22	74.6	94.3	79.0
52269		3.32	74.5	93.9	79.5
52369		3.42	71.8	94.3	78.9
52669	4.4	3.13	71.5	94.4	77.6
52769	4.4	3.12	70.9	94.2	75.7
52869		3.20	70.7	94.2	76.2
52969	5.0	3.22	70.6	93.8	76.2
60269	4.4	3.40	70.1	92.5	77.8
60369	4.4	3.20	26.1	91.6	80.0
60469	4.4	3.02	76.7	91.7	80.4
60669		3.10	75.1	91.1	78.8
60969		3.08	74.1	89.0	80.0
61069		3.20	73.7	88.2	79.5
61169		3.05	73.5	90.5	83.2
61269		3.25	70.5	89.8	81.3
61369		3.10	70.2	89.1	81.6
61769		3.15	72.2	87.0	82.5
61869		3.31	71.3	85.6	82.8
61969		3.30	70.3	84.9	81.9
62069		3.17	71.2	85.2	78.7
62369	2.6	3.23	70.6	82.8	79.4
62469	3.3	3.32	70.0	81.8	79.0
62569	3.3	3.55	70.4	82.7	79.3
62669	3.5	3.28	71.7	82.2	81.2
62769		3.25	71.2	81.4	80.7
63069		3.28	69.9	79.0	80.5
70169		3.35	70.0	78.9	80.5
70269	3.3	3.34	69.8	78.4	80.7
70369		3.32	69.4	77.4	80.9

STATION 20 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
70769	2.7	3.62	59.6	69.5	77.9
70869	3.3	3.23	69.1	74.1	68.7
70969	3.3	3.22	70.2	75.8	68.6
71069	3.3	3.32	69.9	77.4	69.5
71169	3.3	3.38	69.5	76.1	68.2
71469	3.0	3.19	70.8	78.0	80.7
71569	3.3	3.03	68.8	75.8	79.4
71669	3.3	3.00	67.9	75.2	78.1
71769	3.3	3.11	67.6	75.7	78.6
71869	3.3	3.12	66.6	75.8	79.7
72169	3.3	3.28	66.7	74.7	79.3
72269	3.3	3.00	67.4	78.1	80.0
72369	3.0	3.05	66.6	77.5	80.2
72469	3.3	3.08	65.7	76.5	80.4
72569	3.0	3.03	64.8	76.7	79.9
72869	3.0	3.12	71.0	75.7	80.7
72969	3.0	3.18	71.0	76.9	80.3
73069	3.0	3.20	69.8	76.4	80.7
80169		3.25	70.5	75.4	80.7
80469		3.12	69.8	73.5	80.1
80569		3.20	69.3	71.8	79.6
80669	2.4	3.23	68.7	70.2	79.8
80769		3.10	68.9	70.6	80.4
80869	2.4	3.42	68.4	71.2	82.2
81169	2.4	3.12	71.2	72.1	81.5
81269	2.4	3.22	70.8	70.9	81.8
81369	2.4	3.22	69.8	69.7	81.1
81869	2.1	3.28	68.1	68.0	82.2

STATION 20 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
81969	2.1	2.93	65.2	67.3	78.4
82069	2.1	2.98	64.1	66.4	77.0
82169	2.1	2.98	63.2	64.9	76.5
82269	2.1	3.00	62.4	64.1	77.0
82569	2.1	3.23	61.7	63.0	78.5
82669	2.1	3.12	67.4	63.2	76.9
82769	2.1	3.15	67.1	62.0	78.1
82869	2.1	3.12	66.1	61.9	76.9
82969	2.1	3.10	66.1	60.2	76.9
90269	2.1	3.30	65.5	59.4	77.7
90369	2.1	3.13	65.5	58.9	79.2
90469	2.1	2.96	65.0	59.5	78.8
90569	2.0	2.96	64.6	58.3	78.5
90869	2.0	3.10	63.8	20.5	78.7
90969		3.03	63.3	20.3	78.9
91069	2.0	3.16	63.3	55.6	79.8
91169		3.34	62.7	52.1	80.4
92269	2.0	3.06	47.7	51.3	78.8
92369	2.2	3.11	46.9	50.6	78.5
92469		3.12	46.4	51.1	78.0
92569	2.2	3.15	47.0	51.0	78.2
92669	2.2	3.15	47.5	51.3	78.1
92969	2.4	3.10	42.3	55.5	79.2
93069	2.4	3.14	47.1	54.5	77.9
100169	2.4	3.21	41.0	52.9	77.0
100269		3.12	41.9	54.1	76.2
100369		3.18	41.6	52.8	75.9

STATION 22 (7117 PORTAL)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
40769	0.8	3.69	18.7	16.0	0.1
40869	0.2	3.68	17.9	16.5	0.1
40969	1.3	3.23	17.1	15.5	0.1
41069	1.7	3.81	15.9	14.2	0.1
52369		3.75	39.7	26.6	18.0
52669	4.3	3.55	36.9	22.8	22.6
52769	5.0	3.52	37.3	41.4	76.9
52869		3.58	36.8	21.4	77.1
52969	4.4	3.63	36.6	20.7	77.2
60269	4.0	3.73	37.7	18.9	27.5
60369	4.0	3.38	39.2	17.4	7.5
60469	4.0	3.43	38.6	17.0	9.9
60669		3.48	41.4	21.0	11.5
60969		3.59	40.4	16.6	19.1
61069		3.62	39.7	16.8	17.1
61169		3.40	40.0	17.2	16.7
61269		3.43	39.3	18.4	14.5
61369		3.47	39.0	16.8	19.3
61669		3.58	38.4	19.1	22.1
61769		3.50	40.0	17.8	17.8
61869		3.68	39.7	18.1	24.3
61969		3.63	39.1	17.5	30.7

STATION 22 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
62069		3.56	39.2	17.2	16.2
62369	3.0	3.63	39.8	15.9	21.0
62469	3.0	3.68	40.3	16.7	24.5
62569	3.0	3.48	39.2	16.8	36.7
62669	3.0	3.67	40.1	16.3	16.6
62769		3.63	40.7	16.0	15.0
63069	3.7	3.66	39.9	15.5	17.0
70169	3.0	3.72	40.3	15.7	18.2
70269	3.0	3.73	41.0	16.2	19.2
70369		3.72	40.3	16.2	20.8
70769	3.0	3.83	40.0	15.7	32.6
70869	3.0	3.61	40.2	15.7	78.9
70969	3.0	3.58	42.1	16.5	79.4
71069	3.0	3.68	43.0	16.6	79.7
71169	3.0	3.66	43.3	17.3	79.8
71469	3.3	3.57	47.1	19.6	26.6
71569	2.9	3.43	44.7	17.8	13.4
71669	2.7	3.46	43.8	18.1	13.9
71769	2.7	3.48	43.3	17.9	14.2
71869	2.7	3.50	42.7	17.7	17.2
72169	2.7	3.60	42.4	17.9	27.1
72269	2.7	3.42	44.5	19.0	13.0

STATION 22 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
72369	2.7	3.45	44.)	19.)	13.2
72469	2.7	3.50	42.8	18.6	14.0
72569	2.7	3.52	42.5	19.2	17.4
72369	2.7	3.50	45.8	17.8	12.1
72969	2.7	3.60	45.6	13.8	15.3
73)69	2.7	3.58	45.4	19.4	18.2
73169	2.7	3.60	47.8	19.7	18.0
80169		3.63	47.6	19.4	20.2
8)469		3.5)	48.2	19.8	19.4
80569	2.1	3.57	48.5	20.1	20.3
80669	3.0	3.62	48.5	20.7	22.5
80769	2.	3.43	48.1	20.0	25.4
80869	2.1	3.70	48.1	20.2	46.6
81169	2.1	3.48	51.2	23.3	23.9
81269	2.0	3.57	51.4	24.8	24.9
81369	2.0	3.56	50.6	24.7	21.7
81869	2.0	3.56	42.8	24.0	29.0
81969	2.0	3.30	47.5	22.5	12.2
82)69	2.)	3.36	46.3	21.9	17.1
82169	2.0	3.33	45.7	21.4	12.2
82269	2.0	3.36	45.2	21.8	16.9
82569	2.)	3.52	45.3	21.8	32.6

STATION 22 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
82669	2.0	3.45	49.3	22.2	16.3
82769	2.0	3.55	47.6	22.2	17.5
82869	2.)	3.53	47.9	22.8	18.4
82969	2.0	3.50	49.1	23.2	17.6
90269	2.0	3.60	46.0	21.3	29.5
90369	2.)	3.4)	45.7	21.5	16.1
90469	2.0	3.30	48.0	23.1	19.3
90569	1.9	3.38	49.7	23.3	21.)
90869	1.9	3.43	43.3	11.6	18.6
90969		3.42	43.8	11.5	21.1
91)69	1.9	3.48	44.6	20.9	31.8
91169		3.60	44.4	19.4	43.0
92269	2.0	3.38	28.3	19.3	22.8
92369	2.0	3.47	24.4	17.0	18.1
92469		3.48	26.7	18.9	
92569	2.)	3.48	25.2	18.5	18.7
92669	2.0	3.50	25.7	18.7	21.2
92969	2.1	3.44	24.1	19.8	22.9
93)69	2.1	3.49	24.7	2).5	18.5
100169	2.1	3.56	24.5	20.4	20.8
100269		3.47	25.9	20.5	21.9
100369		3.68	26.1	20.8	21.4

STATION 23 (BUCKTAIL CREEK)

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
42569	40.0	4.12	65.9	94.6	1.2
42869	60.0	4.05	65.4	94.6	2.2
42969	75.)	3.98	67.2	95.0	4.2
43069	60.0	4.00	68.6	94.5	1.2
50169	50.)	4.12	68.4	94.)	1.3
50269	50.0	4.05	68.2	93.9	0.9
50569	60.0	4.22	69.9	94.2	2.5
50669	4).)	4.)5	64.4	94.9	1.2
50769	75.0	4.10	62.5	94.4	1.3
50869	100.0	4.22	60.9	93.8	1.4
50969	100.0	4.18	58.1	93.5	1.3
51269	150.0	4.38	49.9	91.6	0.7
51369	3)).)	4.48	49.8	91.3	1.)
51569		4.28	50.2	91.3	
51669		4.35	49.4	90.7	0.4
52)69		4.2)	52.7	92.1	
52169		4.44	49.6	91.5	
52269		4.62	5).1	91.3	
52369		4.58	50.5	91.4	
52669		4.44	41.9	89.7	76.4
52769		4.38	4).6	88.3	76.5
52869		4.40	41.5	89.2	74.9
52969		4.80	42.4	89.7	75.8
60269		4.40	45.7	91.5	0.6
60369		4.30	49.8	91.0	0.4
6)469		4.)2	51.3	91.3	0.3
60669		4.13	53.5	93.0	0.6
60969		3.70	53.3	91.7	7.2

STATION 23 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
61069		4.33	53.3	91.9	0.9
61169		4.4)	53.4	94.)	).6
61269		4.30	53.2	93.9	0.4
61369		4.00	54.4	94.4	1.0
61669		4.34	56.5	95.2	2.3
61769		4.32	59.8	93.8	1.7
61869		4.25	59.4	94.1	2.3
61969		4.32	58.7	93.8	1.6
62069		4.32	60.7	93.6	1.0
62369	1)).)	4.28	6).6	93.3	1.9
62569	100.0	3.98	75.4	94.4	32.1
62669	100.0	4.42	69.0	93.5	0.7
62769		4.13	71.8	93.3	0.6
63069	60.0	4.22	69.3	93.4	0.5
70169	60.0	4.22	62.)	93.3	).4
70269	60.0	4.32	62.6	93.4	0.3
70369		4.23	62.1	93.1	0.7
7)769	7).)	4.12	59.7	92.8	4.)
70869	60.0	4.28	63.3	94.2	78.6
70969	60.0	4.22	63.3	95.6	78.3
71069	60.0	4.32	63.0	95.4	78.6
71169	60.0	4.15	62.4	95.1	77.8
71469	6).)	4.26	63.4	95.4	74.)
71569	60.0	4.18	61.3	94.6	1.0
71669	42.8	4.26	60.0	94.4	0.9
71769	42.8	4.22	59.8	94.4	1.2
71869	42.8	4.25	59.4	94.3	0.9
72169	42.8	4.26	59.3	94.2	1.5

STATION 23 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
72269	42.8	4.12	60.5	94.2	1.4
72369	37.5	4.18	60.0	94.1	1.5
72469	42.8	4.25	59.5	94.1	1.3
72569	42.8	4.28	58.6	94.0	1.9
72369	37.5	4.28	65.2	95.2	1.0
72969	37.5	4.40	64.4	95.3	1.5
73069	37.5	4.40	63.4	95.2	1.4
73169	37.5	4.45	64.1	95.4	1.4
80169		4.40	65.3	95.3	1.2
80469	33.3	4.32	64.3	94.7	24.3
80569	33.5	4.38	63.4	94.7	1.2
80669		4.42	63.2	94.5	1.4
80769	30.0	4.23	63.8	94.7	1.8
80869		3.35	62.7	94.6	2.8
81169	30.0	4.43	66.5	94.3	0.9
81269	30.0	4.35	65.5	94.2	0.8
81369	30.0	4.43	63.7	94.3	0.9
81869		4.26	63.7	94.5	1.4
81969		4.12	61.4	94.8	0.3
82069	25.0	4.18	59.9	94.8	0.7
82169	27.2	4.27	59.4	94.9	1.1
82269	25.0	4.32	59.0	94.8	1.1
82569	25.0	4.25	58.8	94.8	2.0

STATION 23 CONTD

DATE	FLOW (GPM)	PH	CO (PPM)	CU (PPM)	FE (PPM)
82669	25.0	4.43	64.1	94.1	0.7
82769	25.	4.22	62.9	94.0	0.7
82869	25.0	4.46	62.8	94.1	0.5
82969	25.0	4.32	63.2	94.2	0.3
90269	25.0	4.42	62.9	94.3	2.0
90369	25.0	4.25	62.1	94.3	0.5
90469	23.0	4.15	61.8	94.5	
90569	25.0	4.22	61.6	94.1	0.6
90869	20.0	4.18	61.0	69.1	1.0
90969		4.12	60.8	69.1	0.9
91069	21.4	4.02	60.6	94.2	1.0
91169		4.17	60.1	95.3	1.0
92269	20.0	3.96	45.5	94.5	0.7
92369	21.0	4.00	44.8	94.6	1.2
92469		3.98	45.7	94.5	1.0
92569	21.0	4.00	44.3	94.6	1.5
92669	21.0	4.28	46.2	94.4	1.9
92969	17.5	3.83	40.8	99.0	4.5
93069	17.5	4.12	43.9	99.3	0.9
100169	17.5	4.01	41.1	99.3	0.6
100269			41.7	99.1	1.4
100369		4.02	40.9	97.2	1.4

Appendix II-2. Water quality and quantity data for 1971 from the Blackbird Mining Area. Samples collected by the Idaho Mining Company. USDA Forest Service, and Idaho Department of Health.

STATION 1B (8)

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
33171		).335	).)13	).125
41171		.248	.059	.40
41971		.143	.046	.701
50371		.34	.25	4.98
51071		.102	.051	1.21
51771		.)25	.)33	.62
52671		.032	.015	.57
53171		.024	.094	1.15
60771		.)09	.)09	.73
62171		-.01	.026	.14
62871		-.01	.)18	.23
71271		-.01	.016	.43
71971		-.01	.016	.17
80271		-.)1	.)21	.23
90171		-.01	.016	.33
100471		-.01	.024	.35
110171		-.01	.012	.19
120271		-.01	.016	.21

STATION 2B (6)

22571			7.44	25.07
33171		5.97	31.03	20.17
41171		12.52	7.31	6.93
41471	1.52	11.43	6.80	17.19
41471		20.45	10.60	19.60
41971		10.95	6.61	20.73
42671		20.25	10.60	19.60
50371		9.04	7.80	35.80
50571	13.2	9.53	9.79	8.39
50571		12.36	30.70	53.42
51071	15	3.94	2.95	11.41
51771	18	2.18	2.72	6.78
52671	15.	2.16	2.69	10.4
52871	43.7	1.)8	2.99	12.82
53171	23	1.18	7.88	0.80
60171		1.04	2.23	6.18
60271		1.04	2.80	5.68
60371		1.08	2.64	5.80
60771	33	).97	1.35	4.44
61571	24.3	0.85	2.10	3.55
61571		1.20	1.72	5.31
62171		).88	).77	5.83
62171		0.81	1.83	5.01
62471	17.4	1.56	2.)7	7.82
62471		1.03	1.65	6.17
62871		1.44	2.06	9.84
70671		1.68	2.71	14.86
71271		1.99	3.03	30.45

STATION 2B CONTD

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
72071	2.72	2.72	3.90	23.90
71971		2.92	4.13	42.28
80271		3.65	5.))	28.92
90171	1.83	4.50	4.56	35.96
100471		3.07	3.70	32.52
110171		3.)7	3.60	30.83
110971	1.07	4.25	3.73	34.20
120271		3.75	3.51	3).28

STATION 3B (3)

22571			0.02	0.28
33171		0.021	0.039	0.104
41171		.004	.003	.139
41971		.002	-.001	1.54
50371		.)2)	-.)1	.6)
51071		.008	.009	.54
51771		.019	.011	.595
52671		.)1)	.010	.592
53171		.005	.071	1.)8
60771		.016	.)03	.382
62171		-.01	0.051	.382
62871		-.01	0.012	.136
70671		-.)1		.176
71271		-.01	.009	.18
71971		-.01	.016	.15
80271		-.01	.014	.159
100471		-.01	.017	.207
110171		-.)1	.)17	.476

STATION 685) PORTAL (7)

33171		11.3	49.7	54.9
41171		12.8	8.9	65.2
41971		14.7	9.1	151.1
50371		21.6	44.6	283.6
51071		23.4	55.1	193.9
52671		28.8	31.5	224.5
53171		28.8	191.8	229.9
60771		24.4	17.1	276.2
62171	.22	22.3	8.0	283.3
62871	.10	20.5	15.7	448.2
71271	.11	37.9	27.0	130.8
71971		25.9	33.6	687.4
80271	.)8	19.7	2).6	39).7
90171		19.4	11.0	426.7
100471		14.4	5.4	345.5
110171	.10	14.9	4.5	350.4
120271		14.1	3.9	342.6

STATION 4B (2)

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
22571			-.01	1.06
33171		.485	.154	1.44
41171	12.5	.055	.005	.22
41471	3.8	.062	.013	.46
41471		.09	.001	1.23
41971	12.5	.057	.013	.007
42671	12.5	.09	-.01	1.23
50371	35	.03	-.01	1.12
50571	47	.024	.017	3.17
50571		-.01	.01	1.36
51071	60	.017	.012	.68
51771	52	.012	.008	.76
52671	37.5	.019	.010	.62
52871	87.1	.02	.03	7.49
53171	2.9	.008	.071	1.02
60171		.012	.016	.63
60271		.15	.016	.69
60371	9.3	.012	.016	.52
60771		.016	.005	.53
61571	37.6	.018	.031	1.00
61571		-.01	-.01	.34
62171		-.01	.051	.33
62171		.007	.016	.28
62471	24.6	.019	.018	.38
62871		.015	.014	7.49
70671		.015	.016	.49
71271	5.1	.024	.016	.74
72071	5.1	.040	.014	.81
80271		.024	.012	.62
90171	0.8	.060	.014	1.38
100471		.064	.014	1.58
110171		.072	.016	2.35
110971	1.1	.116	.014	2.12
120271		.015	.014	.35

STATION 5B

22571			0.80	4.43
33171		2.18	5.99	0.17
41171		3.39	1.13	1.69
41471	13.9	3.63	1.18	2.51
41471		7.79	1.37	4.39
41971		1.78	.54	2.31
42671		7.79	1.37	4.39
50371	70	2.27	.68	12.56
50571	101	2.26	1.44	
50571		3.56	4.74	54.30
51071	79.	1.31	1.05	7.77
51771		.87	.68	8.09

STATION 5B CONTD

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
52671		.85	.64	8.21
53171		.74	3.70	27.82
60171		.46	.30	5.21
60271		.53	.41	8.09
60371		.41	.58	4.15
60771		.61	.47	10.41
61571	74.7	.50	.59	1.94
61571		.36	.37	1.60
61771		.24	.37	3.34
61971		.43	.49	1.95
62171		.54	.33	2.00
62171		.42	.65	2.16
62471	39.5	.65	.69	2.58
62471		.55	.53	2.17
62871		.51	.50	2.92
63071		.47	.84	3.39
70671		.60	.95	4.29
71271		.78	1.42	5.01
71971		.54	1.01	2.00
72071	9.55	1.09	1.53	5.06
80271		1.79	1.28	3.29
90171	4.22	1.59	1.73	4.34
100471		1.57	1.46	4.53
110171		1.73	1.67	3.20
110971	3.35	2.33	1.98	4.10
120271		2.92	2.37	3.40

STATION 6B

22571			0.130	0.90
41171		-.001	.006	0.15
41971		.563	.175	1.32
50371		.215	.054	2.25
51071		.227	.159	2.31
51771		.131	.099	2.50
52671		.150	.104	1.87
53171		.121	.712	3.61
60771		.066	.066	2.16
61171		.062	.095	1.52
62171		.050	.028	0.42
62871		.053	.071	0.67
70671		.068	.078	0.61
71271		.062	.069	0.67
71971		.080	.098	0.60
80271		.096	.111	0.72
100471		.082	.209	0.19
110171		.406	.254	0.44
120271		.406	.254	0.44

22571			-.01	.06
33171		.015	.058	.231
41171	170	.912	.176	1.22
41471	68.8	.107	.036	.40
41471		.49	-.001	.26
41971	126	.007	.005	.461
42671	170	.49	-.01	.26
50371	239	-.01	-.01	.47
50571	345	.006	.006	.12
51071	320	.006	.011	.94
51771	354	.016	.009	1.13
52671	284	.010	.007	.784
53171		.002	.524	.872
60171		-.01	-.01	.51
60271		-.01	-.01	.44
60771		-.002	-.002	.626
61171		-.01	-.01	.97
61571	746	-.002	.005	1.00
61571		-.01	-.01	.60
61771	403	-.01	-.01	.17
61971		-.01	-.01	.09
62171		.025	.025	.31
62171		.013	.013	.39
62471	549	.012	.012	.40
62871	772	-.01	-.01	.44
63071	420	-.01	-.01	.18
70671	377	-.01	-.01	.18
71971	299	-.01	-.01	.21
72071	133	-.01	-.01	1.15
80271	377	-.01	-.01	.23
90171	53.2	-.01	-.01	.32
100471		-.01	-.01	.27
110171		-.01	-.01	.24
110971	43.9	-.01	-.01	.26
120271		-.01	-.01	.14

STATION 1M (1JA)

33171	.16	13.0	58.7	19.6
41171	.35	17.3	13.7	15.7
41471	.21	32.6	18.8	20.9
41471		50.5	16.4	42.8
41971	.35	22.9	16.6	36.1
42671		50.5	16.4	42.8
50371		21.6	44.6	283.6
50571	3.30	18.7	21.5	22.2
50571		19.8	51.9	82.8
51071	2.58	11.3	14.3	25.4
51771		8.5	11.3	13.4
52671		9.2	11.8	18.9
52871	4.31	14.1	5.6	41.7
53171		4.6	38.0	22.3
60171		4.6	11.3	14.2
60271		5.3	12.0	13.9
60371		5.6	13.2	7.4
60771		6.1	7.3	6.9
61571	1.93	5.7	12.2	8.9
61571		5.2	11.3	7.0
61771		4.8	10.4	8.8
61971		6.7	14.1	9.1
62171	1.7	6.3	6.9	7.6
62471	1.15	7.9	15.3	9.3
62471		9.2	19.6	12.7
62871	.30	10.0	19.9	13.1
63071		8.9	16.7	10.9
71271		10.0	15.4	15.1
71971		10.8	13.2	15.5
72071	.27	10.3	12.9	15.8
80271		15.8	15.8	13.8
90171	0.09	13.4	13.4	21.0
100471		13.5	13.5	19.3
110171		13.1	13.1	22.5
110971	0.22	8.8	8.8	15.2
120271		9.4	9.4	14.5

STATION 6P

22571			.04	-.01
33171		.547	.481	.343
41171		.110	.045	.293
41471	4.14	.099	.081	.091
41971		.067	.059	.599
42671		.21	.08	.05
50371		.119	.080	.36
50571	131.	.123	.062	.022
50571		.32	1.09	1.84
51071	225.	.249	.593	1.38
51771	256	.179	.360	.813
52671	135	.246	.537	.566
52871	209	.15	.73	1.12
53171		.249	3.71	1.66
60171		.28	1.20	.59
60771		.191	.332	.304
61171		.15	.90	.59
61571	264	.133	.59	1.48
61571		.18	.75	1.15
62171		.10	.30	3.54
62171		.12	.76	.91
62471	220	.096	.442	1.27
62471		.12	.51	1.49
62871	256.	.20	.53	.14
63071		.24	.58	.26
70671		.20	.55	.26
71271	46	.15	.48	.39
71971		.08	.36	.20
72071	65.4	.15	.55	.39
80271		.24	.70	.33
90171	13.1	.28	.85	.20
100471		.20	.19	.26
110171		.12	.31	.88
110971	11.3	.15	.29	1.00
120271		.12	.21	1.25

STATION 8P

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
22571	105		.01	.17
33171	134	1.07	.219	.229
41171	171	.208	.018	.298
41471	181	.253	.032	.628
41471		.58	.084	.64
505711280		.127	.051	.239
50571		.32	.50	4.91
531712850		.121	.811	3.32
603712110		.033	.062	.153
607711960		.196	.104	2.17
611712410		.066	.121	3.05
615712300		.069	.10	3.65
61571		.06	.10	3.59
621711810		.045	.11	3.57
624711760		.045	.111	7.45
62471		.06	.08	2.15
72071	428	.066	.098	.60
90171	157	.078	.082	.435
100471		.057	.049	.147
110171		.083	.069	.40
110971		.095	.069	.235
120271		.054	.035	.092

STATION 10P

33171		1.57	.374	.290
41171		.532	.115	1.33
41971		.289	.085	1.24
50371		.086	-.01	4.40
51071		.113	.046	.575
51771		.093	.057	2.63
52671		.073	.056	1.81
53171		.096	.436	3.40
60771		.032	.018	.977
61171		.047	.053	2.55
61771		.036	.046	1.47
61971		.042	.048	.36
62171		.041	.015	.911
62871		.025	.032	.78
63071		.029	.032	3.40
70671		.046	.046	.51

STATION 10P CONTD

DATE	FLOW (CFS)	CO (PPM)	CU (PPM)	FE (PPM)
71271		.039	.046	.52
80271		.067	.051	.35
90171		.075	.048	.386
100471		.050	.032	.10
110171		.122	.087	.55
120271		.075	.035	.047

STATION 11P

33171		1.79	.65	.55
41171	533	.50	.10	.98
41471	136	.36	.11	.63
41471		.78	.09	.68
41971	240	.32	.09	1.20
42671		.78	.09	.68
50371	650	.02	-.01	2.35
505711080		.16	.07	.30
50571			.44	5.87
510711080		.12	.08	1.83
517711260.		.10	.07	2.89
52671	968	.09	.06	2.02
528711990		.19	.03	12.0
53171		.10	.42	3.32
60171		1.08	1.22	9.42
60771		.02	-.01	.01
615711920		.06	.13	3.17
61571		.09	.12	3.18
61971		.06	.05	.36
62171	912	.05	.02	.78
62171		.05	.13	2.98
624711420		.39	.05	1.42
62471		.05	-.01	.34
62871	912	.04	.05	1.85
70671	542	.03	.05	.73
71271	430	.03	.05	.69
72071	280	.07	.06	.56
80271		.06	.06	.28
90171	115	.06	.05	.31
100471		.08	.05	.20
110971	71.5	.12	.07	.34

Appendix III-1. Water quality data for 1974, 1975, and 1976 from the Blackbird Mining Area. Samples collected by University of Idaho personnel.

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
61974	1	0.0	0	0.5	0.1	0.7	0.1	2.0	3.0	1.8
72174	1	3.9	190	1.6	1.5	0.4	0.6	0.0	0.0	0.0
72374	1	3.8	200	1.8	1.7	0.4	0.8	5.5	7.2	2.4
80474	1	3.9	210	1.9	1.9	0.5	1.1	0.0	0.0	0.0
81174	1	3.9	220	2.0	1.6	0.5	0.3	0.0	0.0	0.0
81374	1	3.8	220	1.2	1.7	-0.1	0.8	0.0	0.0	0.0
82574	1	3.7	200	2.5	1.6	-0.1	0.9	4.9	5.3	2.7
100574	1	0.0	0	2.3	1.7	0.0	0.9	0.0	0.0	3.0
110274	1	0.0	360	2.6	1.6	0.1	0.9	0.0	0.0	0.0
51975	1	0.0	0	3.0	2.9	3.6	4.0	0.0	0.0	0.0
60475	1	4.1	0	0.7	1.7	0.3	-0.1	2.1	4.0	0.0
60975	1	0.0	0	0.3	1.4	0.2	0.4	1.7	1.2	0.0
70175	1	4.9	95	0.5	0.4	0.3	0.4	2.9	4.5	0.0
80175	1	4.1	200	1.4	0.9	0.3	0.5	5.6	7.5	0.0
72876	1	4.7	1000	2.0	1.3	2.7	0.6	4.9	5.2	3.6
72174	2	6.1	80	-0.1	-0.1	0.1	-0.1	0.0	0.0	0.0
72674	2	6.3	80	-0.1	-0.1	-0.1	-0.1	2.5	6.0	1.7
80474	2	6.2	85	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81174	2	5.8	90	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81374	2	6.3	100	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
82974	2	6.1	120	-0.1	-0.1	-0.1	2.6	0.0	0.0	0.0
100574	2	0.0	0	-0.1	-0.1	1.1	0.2	2.7	0.0	0.0
110274	2	0.0	120	0.1	0.0	1.2	0.1	0.0	0.0	0.0
51975	2	0.0	0	0.1	0.0	1.5	2.2	0.0	0.0	0.0
60475	2	0.0	0	0.2	-0.1	0.2	-0.1	1.1	2.7	0.0
60675	2	4.6	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60975	2	0.0	0	1.0	0.4	0.3	0.1	1.7	0.8	0.0
70175	2	5.0	50	-0.1	0.1	-0.1	-0.1	2.0	3.6	0.0
80175	2	6.2	90	0.2	0.2	0.4	-0.1	2.7	6.0	0.0
72876	2	7.3	53	0.4	0.0	0.5	0.5	2.5	4.6	4.1
72876	2A	2.9	650	6.8	0.0	45.0	3.3	6.8	76.2	11.2
72174	3	6.3	65	-0.1	-0.1	-0.1	0.2	0.0	0.0	0.0
72374	3	6.4	70	-0.1	-0.1	-0.1	0.0	2.3	4.9	1.6
80474	3	6.6	80	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
81174	3	6.4	60	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
60475	3	4.0	50	0.3	-0.1	1.4	0.1	0.7	3.1	-0.1
70175	3	5.3	50	-0.1	0.1	0.1	-0.1	1.7	3.9	0.0
80175	3	5.5	60	-0.1	-0.1	0.3	-0.1	1.8	4.8	0.0
72876	3	7.5	45	0.4	0.0	0.5	0.5	2.3	3.9	3.2
72174	4	3.4	300	2.4	3.0	0.7	0.9	0.0	0.0	0.0
72374	4	3.2	300	2.8	2.6	0.4	1.2	6.3	5.9	1.6
80474	4	3.3	320	1.9	2.4	0.7	1.1	0.0	0.0	0.0
81174	4	3.3	380	2.4	2.3	1.1	1.1	0.0	0.0	0.0
81374	4	3.3	400	2.5	3.0	-0.1	1.5	7.4	5.2	2.9
82574	4	3.2	420	3.4	2.3	0.7	1.5	0.0	0.0	3.0
100574	4	0.0	0	3.4	2.6	0.7	1.5	0.0	0.0	3.0
110274	4	0.0	0	3.6	2.8	0.4	1.4	0.0	0.0	0.0
123174	4	0.0	0	3.8	2.0	3.0	1.2	0.0	0.0	0.0
41975	4	3.3	0	2.9	1.8	3.0	3.0	6.0	5.9	2.6
51975	4	0.0	0	3.2	5.1	4.8	4.7	0.0	0.0	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
60475	4	4.2	180	1.6	5.6	0.3	-0.1	3.3	3.9	-0.1
60975	4	4.1	125	3.9	3.5	0.9	0.4	2.5	1.1	-0.1
70175	4	4.0	125	0.8	1.3	0.6	0.3	3.7	4.6	0.0
80175	4	3.2	250	2.8	3.6	3.3	0.7	7.2	6.9	0.0
100475	4	0.0	410	0.9	2.7	3.3	-0.1	7.8	2.8	1.1
31976	4	3.3	240	2.0	1.4	2.4	0.6	4.9	7.0	0.0
40376	4	3.9	260	2.5	2.2	1.5	0.9	5.5	7.3	0.0
40676	4	3.7	260	3.2	3.1	9.5	1.4	7.1	4.2	3.6
41376	4	3.9	260	2.2	3.4	2.8	0.3	5.1	1.6	2.8
41976	4	3.8	320	2.4	4.8	0.2	0.6	5.7	7.9	6.3
42276	4	3.7	300	2.7	5.3	-0.1	0.6	5.8	7.1	5.7
42676	4	3.8	0	2.4	5.2	0.3	0.6	1.9	4.0	6.4
42376	4	3.8	320	2.5	5.1	5.2	0.7	6.3	4.5	3.1
42976	4	3.7	330	2.6	4.9	4.7	0.7	35.9	4.9	3.2
50176	4	3.8	300	2.7	4.9	2.2	0.6	6.4	3.6	3.0
50476	4	3.9	260	2.3	6.3	3.3	0.5	4.5	2.7	3.8
50876	4	4.0	260	2.2	6.8	2.5	0.4	4.7	2.3	2.9
50676	4	4.0	260	1.7	4.3	8.4	0.4	4.4	2.9	3.1
51776	4	3.9	230	2.6	4.7	3.6	0.5	4.4	3.3	2.6
50876	4	3.7	280	2.9	6.8	2.5	0.6	5.0	3.4	2.5
51076	4	4.0	240	2.4	6.0	4.0	0.5	4.7	3.0	2.0
51176	4	3.8	230	2.2	4.7	2.1	0.4	3.8	3.5	2.5
51276	4	4.2	200	1.9	4.1	3.0	0.4	3.8	3.6	2.7
51376	4	4.3	185	1.9	4.3	3.3	0.4	3.8	4.0	1.6
51476	4	4.4	0	1.8	2.9	10.3	0.3	3.5	3.4	3.8
51976	4	4.3	0	2.0	2.5	2.3	0.0	3.6	2.7	0.0
52376	4	4.7	0	2.0	1.5	1.9	0.0	3.1	4.6	0.0
62976	4	4.4	1450	1.8	1.5	3.1	0.7	50.6	13.3	3.6
71276	4	3.7	200	1.7	1.9	2.8	0.8	5.9	3.8	4.5
71576	4	3.0	200	2.2	2.3	6.0	0.5	5.7	7.4	4.3
72076	4	3.6	210	2.5	2.4	2.2	0.7	5.7	7.5	5.1
72876	4	3.6	220	4.1	1.4	4.2	0.8	6.2	5.2	4.5
80376	4	3.6	270	2.8	2.6	4.5	0.9	6.6	7.5	2.9
72174	5	5.9	50	0.3	-0.1	-0.1	-0.1	0.0	0.0	0.0
72874	5	5.4	65	-0.1	-0.1	-0.1	-0.1	2.2	2.1	1.6
80474	5	5.9	70	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81174	5	5.8	60	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
82574	5	5.9	100	-0.1	-0.1	-0.1	-0.1	2.2	2.3	2.2
100574	5	0.0	0	0.3	-0.1	-0.1	-0.1	0.0	0.0	2.5
60475	5	3.8	50	0.5	-0.1	0.5	-0.1	0.6	1.6	0.0
60975	5	4.4	50	1.3	0.2	0.1	0.3	0.6	0.7	0.0
70175	5	4.8	50	-0.1	0.1	-0.1	0.3	3.7	4.6	0.0
80175	5	6.0	70	-0.1	-0.1	-0.1	-0.1	1.5	2.0	0.0
72174	6	3.3	380	3.1	4.4	2.0	1.4	0.0	0.0	0.0
72874	6	3.2	420	3.8	4.8	0.7	1.8	9.8	7.5	1.5
80474	6	3.2	400	2.8	4.3	1.0	1.7	0.0	0.0	0.0
81174	6	3.1	460	3.7	4.3	1.4	2.0	0.0	0.0	0.0
81374	6	3.2	500	4.3	4.8	0.7	2.1	0.0	0.0	0.0
82574	6	3.1	550	4.5	4.3	1.3	2.7	4.9	7.0	2.1
101574	6	0.0	0	4.8	3.6	3.2	2.5	0.0	0.0	2.8

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
110274	6	0.0	0	4.8	4.2	1.4	2.2	0.0	0.0	0.0
50475	6	3.3	230	4.3	10.2	1.1	0.2	4.3	4.3	0.0
60975	6	3.7	145	4.2	5.5	3.4	0.5	3.4	0.9	0.0
70175	6	4.1	120	3.4	1.6	3.0	0.6	4.1	7.1	0.0
80175	6	3.1	320	4.0	5.7	23.3	1.2	10.6	8.2	0.0
100475	6	0.0	460	1.3	4.3	2.5	0.0	12.2	3.3	2.0
40376	6	3.5	440	3.5	4.5	6.7	1.3	8.4	6.5	0.0
51976	6	5.1	0	2.0	3.7	4.0	0.0	4.6	3.3	0.0
72876	6	3.3	320	6.3	3.8	12.2	1.2	9.2	6.5	4.2
61974	7	0.0	2230	30.0	27.5	200.0	10.0	50.0	9.0	6.1
72174	7	2.9	1750	19.5	8.8	26.0	8.8	0.0	0.0	0.0
72874	7	2.9	1600	20.5	8.0	24.8	9.1	9.8	7.5	1.5
80474	7	2.7	1600	18.3	8.2	30.4	9.3	0.0	0.0	0.0
81174	7	2.8	1700	17.4	6.6	29.6	9.9	0.0	0.0	0.0
81874	7	2.9	1700	17.7	7.5	37.8	9.1	0.0	0.0	0.0
82574	7	2.8	1900	18.7	8.3	23.9	10.1	5.0	7.0	2.2
82574	7	2.8	1900	18.7	8.3	23.9	10.1	4.9	7.0	2.1
100574	7	0.0	0	17.9	5.0	91.2	5.2	0.0	0.0	7.4
110274	7	0.0	0	13.4	3.9	200.1	8.7	0.0	0.0	0.0
113074	7	0.0	0	14.5	3.2	250.0	8.7	37.5	14.0	6.8
123174	7	0.0	0	13.0	3.0	218.0	7.5	0.0	0.0	0.0
32575	7	0.0	0	10.9	2.5	81.7	7.5	31.4	16.1	20.0
42175	7	2.6	0	10.8	4.1	114.0	7.6	36.1	14.0	11.7
51975	7	0.0	0	17.5	55.0	270.0	40.0	0.0	0.0	0.0
60475	7	2.8	1350	30.0	131.0	208.0	4.9	119.0	3.1	0.0
60975	7	2.6	1100	26.5	78.2	50.8	5.9	36.0	1.7	0.0
70175	7	2.5	1800	30.4	33.0	87.5	10.8	22.1	13.6	0.0
80175	7	2.4	1300	21.8	11.7	246.0	11.3	46.9	25.7	0.0
40376	7	3.0	1150	9.5	2.7	159.0	3.2	14.5	9.5	0.0
40676	7	3.2	1300	8.3	10.9	133.0	5.8	71.8	48.6	6.5
40976	7	4.2	1400	7.3	8.9	146.0	5.1	69.3	11.7	9.0
41376	7	2.7	1800	10.6	20.0	203.0	6.0	73.2	9.1	18.5
41576	7	2.5	0	10.2	16.3	193.0	6.0	74.2	9.7	49.1
41976	7	2.7	1400	9.1	12.6	180.0	7.1	32.0	15.7	12.0
42276	7	2.7	1500	9.2	10.9	93.4	4.0	33.0	14.0	11.8
42476	7	2.7	0	8.9	12.0	12.5	7.3	38.0	14.0	9.0
42676	7	2.8	0	9.6	19.3	225.0	6.7	32.5	13.5	11.2
42876	7	2.7	1300	9.9	15.1	110.0	6.0	32.5	11.6	7.8
42976	7	2.7	1500	10.0	13.0	117.0	6.7	6.4	12.3	8.1
50176	7	2.8	0	9.3	12.5	190.0	5.4	32.5	6.5	6.7
50276	7	2.9	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50476	7	2.8	1600	11.6	67.5	122.0	4.8	27.5	4.0	7.8
50576	7	2.8	1400	10.7	62.5	75.0	4.6	22.3	4.4	6.6
50676	7	2.8	1500	10.7	62.5	95.0	4.3	0.0	3.5	6.8
50776	7	0.0	1500	11.2	40.0	150.0	4.9	22.5	4.9	5.6
50876	7	2.5	1900	12.4	77.5	245.0	4.3	24.0	2.4	5.0
51076	7	2.7	1650	11.6	70.0	152.0	4.2	22.5	2.6	4.4
51176	7	2.5	1300	11.2	55.0	107.0	4.4	20.5	2.7	4.7
51276	7	2.6	1600	10.9	55.0	97.5	4.0	22.5	3.0	2.4
51376	7	2.8	1500	10.6	51.6	86.0	4.8	20.3	3.7	4.2

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
51476	7	2.7	0	10.5	45.3	135.0	4.6	22.0	3.7	5.9
51976	7	3.0	0	15.6	27.4	150.0	5.8	32.0	4.4	0.0
52376	7	3.3	0	13.5	22.5	258.0	7.7	36.0	7.7	0.0
52476	7	3.2	0	12.8	22.5	292.0	8.3	38.0	7.0	0.0
60176	7	2.8	0	20.2	16.0	290.0	8.1	85.0	10.4	7.6
60776	7	2.9	625	19.7	13.6	307.0	8.4	87.1	13.3	12.8
62576	7	3.0	1150	19.4	10.3	282.0	8.5	89.9	12.4	14.5
62976	7	3.0	1100	25.0	5.3	250.0	9.8	43.8	32.5	7.3
71176	7	2.5	0	50.9	35.1	328.0	9.5	48.6	169.0	0.0
71276	7	2.2	0	315.0	1670.0	3000.0	5.6	72.2	9.2	0.0
71376	7	2.7	1740	19.0	6.6	2150.0	12.0	50.0	1.2	9.6
71476	7	2.8	0	33.9	44.6	21.3	0.5	7.6	4.3	0.0
71576	7	2.5	1400	18.0	6.6	295.0	11.6	47.5	30.0	7.3
72076	7	2.7	1600	19.9	7.9	357.0	10.7	45.8	26.5	8.3
72876	7	2.6	1300	39.0	6.9	342.0	9.9	49.6	18.4	8.6
80376	7	2.7	1500	18.1	6.4	547.0	12.0	43.4	27.4	7.2
52875	8	6.1	0	0.2	0.2	0.4	0.9	1.9	4.3	1.6
60475	8	4.4	50	0.4	0.1	0.3	-0.1	1.1	2.7	0.0
60975	8	4.7	50	1.5	0.3	1.2	0.1	1.2	0.8	0.0
70175	8	4.9	50	0.3	-0.1	1.6	-0.1	1.5	3.8	0.0
80175	8	6.1	60	-0.1	-0.1	0.1	-0.1	1.5	5.6	0.0
72876	8	7.5	45	0.4	0.0	0.5	0.5	2.1	9.4	3.0
61974	8	0.0	80	0.1	0.0	0.0	0.0	1.0	4.0	1.2
72174	8	6.5	60	0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
72874	8	6.3	70	-0.1	-0.1	-0.1	-0.1	2.0	5.0	1.5
80474	8	6.3	75	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81174	8	6.3	50	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81874	8	6.6	80	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
82574	8	6.6	120	1.7	-0.1	-0.1	-0.1	2.0	4.0	1.8
100574	8	0.0	0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	1.7
110274	8	0.0	0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
61974	9	0.0	0	23.0	14.0	28.5	3.5	27.0	2.3	3.6
72174	9	3.2	1300	21.6	19.5	7.7	4.7	0.0	0.0	0.0
72874	9	3.1	1200	25.7	19.8	9.7	4.9	34.8	4.8	3.4
80474	9	3.1	1250	25.5	16.6	9.7	5.1	0.0	0.0	0.0
81174	9	3.1	950	25.1	19.5	10.5	5.7	0.0	0.0	0.0
81874	9	3.2	1200	24.7	17.7	3.9	5.0	0.0	0.0	0.0
82574	9	3.1	1100	22.6	15.3	10.2	6.7	35.6	4.1	3.4
100574	9	0.0	0	31.1	12.3	67.8	6.3	0.0	0.0	4.0
110274	9	0.0	1450	31.3	20.6	43.2	5.6	0.0	0.0	0.0
52875	9	3.2	0	27.3	16.6	19.5	3.1	24.6	30.4	3.2
60475	9	3.6	380	5.5	5.5	1.3	1.1	9.0	4.5	0.0
60975	9	3.5	400	10.3	7.0	4.6	1.4	18.7	1.0	0.0
70175	9	2.7	1100	25.5	17.6	85.8	4.9	39.9	4.0	0.0
80175	9	2.7	1100	36.0	30.7	29.9	5.8	38.3	4.8	0.0
50576	9	3.6	600	7.1	11.0	19.0	1.3	16.3	2.4	3.2
50876	9	3.3	540	6.4	7.9	9.8	1.1	13.3	3.1	2.5
51276	9	3.5	460	5.4	6.9	15.0	1.1	11.3	2.5	2.6
51476	9	3.6	0	5.3	6.8	14.4	1.0	9.5	2.5	2.7
52376	9	3.5	0	10.2	9.7	29.5	2.2	20.0	3.0	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
72876	9	3.0	1000	49.9	17.8	73.8	4.8	37.2	3.7	5.3
80376	9	3.0	1000	24.7	19.6	99.4	4.6	32.3	1.7	3.6
61974	10	0.0	1320	24.9	36.5	20.0	2.5	27.5	0.9	1.5
72174	10	3.1	1600	22.8	45.0	3.6	4.1	0.0	0.0	0.0
72874	10	3.0	1600	34.0	51.4	4.1	4.7	34.0	2.5	2.0
80474	10	2.9	1650	26.5	44.0	4.4	4.6	0.0	0.0	0.0
81174	10	3.0	1650	30.6	56.8	6.8	5.2	0.0	0.0	0.0
81874	10	3.1	1600	21.0	46.0	3.9	4.9	0.0	0.0	0.0
82574	10	2.9	1700	23.9	41.0	5.4	5.4	35.8	0.3	2.1
100574	10	0.0	0	41.9	39.6	22.2	6.8	0.0	0.0	2.1
110274	10	0.0	1900	44.7	55.3	62.2	6.1	0.0	0.0	0.0
52875	10	2.8	0	54.4	92.6	51.7	6.8	32.5	2.2	2.4
60475	10	2.9	1250	40.0	107.0	16.8	5.2	159.0	3.0	0.0
60975	10	3.0	1300	106.0	102.0	20.0	5.3	12.2	1.1	0.0
70175	10	2.7	1400	26.6	46.2	60.6	4.3	42.4	0.6	0.0
80175	10	2.4	1300	42.6	58.0	35.9	5.6	52.1	3.5	0.0
31876	10	2.6	1250	31.3	200.0	72.5	6.1	40.8	5.0	0.0
40376	10	3.1	2200	80.0	150.0	240.0	10.6	32.4	2.0	0.0
40676	10	3.1	2600	34.6	75.2	177.0	0.3	86.9	1.6	4.1
41376	10	2.8	2200	34.6	79.6	127.0	5.9	88.6	1.0	3.9
41976	10	2.8	2000	28.3	92.5	99.8	6.7	50.0	2.7	8.4
42276	10	2.7	2200	29.5	117.0	44.4	3.6	50.0	0.4	5.2
42676	10	2.9	1900	27.0	90.0	91.1	6.4	47.5	2.6	5.8
42976	10	2.8	2200	32.4	45.0	47.3	6.6	30.0	1.1	3.3
50576	10	2.9	2150	29.6	107.0	79.8	5.7	45.0	2.6	3.1
50876	10	2.7	2200	20.4	86.3	60.0	5.1	45.0	1.3	2.0
51276	10	2.8	1700	16.8	55.8	65.0	3.8	33.8	0.6	2.7
51476	10	2.8	0	17.1	56.3	62.5	3.7	109.0	0.7	2.0
51976	10	2.9	0	31.0	40.0	51.5	3.4	32.0	0.8	0.0
52376	10	3.0	0	23.3	57.0	47.0	43.0	33.0	2.0	0.0
60176	10	3.0	0	29.1	37.7	41.1	2.8	66.3	1.4	4.4
60876	10	3.0	1225	25.8	27.6	41.9	3.3	70.3	1.1	0.0
62276	10	3.0	1100	28.0	34.5	55.0	5.1	33.5	0.5	2.0
62976	10	3.1	1100	42.7	40.1	61.8	4.4	36.3	1.1	3.7
72876	10	2.8	1300	67.1	49.3	66.0	4.8	49.6	0.6	4.1
80376	10	3.0	600	10.9	21.8	17.5	2.5	20.0	14.7	2.5
61974	10A	0.0	480	6.0	16.0	1.7	1.0	15.5	7.5	2.5
72174	10A	3.3	760	10.2	26.0	1.1	2.9	0.0	0.0	0.0
72874	10A	3.2	800	12.3	22.6	1.4	2.6	24.8	11.2	2.4
80474	10A	3.1	800	11.0	21.4	1.6	2.9	0.0	0.0	0.0
81174	10A	3.2	650	11.4	20.2	2.3	2.8	0.0	0.0	0.0
81874	10A	3.3	650	11.0	20.4	1.0	3.0	0.0	0.0	0.0
82574	10A	3.2	850	7.5	16.3	1.4	2.7	24.1	8.5	2.3
100574	10A	0.0	0	10.6	14.1	8.6	3.8	0.0	0.0	2.8
110274	10A	0.0	850	11.5	16.2	3.8	2.8	0.0	0.0	0.0
52875	10A	3.1	0	18.5	50.1	12.1	2.5	27.1	13.3	2.4
60475	10A	3.4	600	18.7	34.6	1.3	1.3	107.0	6.1	0.0
60975	10A	3.3	500	11.9	38.8	4.1	1.5	9.5	0.8	0.0
70175	10A	3.1	520	9.5	20.5	40.6	0.5	21.4	9.9	0.0
80175	10A	2.8	625	21.3	39.1	19.9	3.1	22.7	12.8	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
10475	10A	2.9	700	2.6	14.6	10.0	0.0	20.8	6.5	2.1
31876	10A	3.2	580	6.6	7.0	6.0	1.8	18.4	17.0	0.0
41976	10A	3.2	1100	17.6	52.5	25.3	3.2	33.0	12.6	7.4
42275	10A	3.2	1150	13.4	52.5	2.0	3.3	35.0	14.2	5.6
42676	10A	3.3	900	10.7	50.0	15.9	2.7	32.3	4.0	6.4
42976	10A	3.2	1100	13.5	87.5	19.2	3.1	50.0	14.8	3.3
50576	10A	3.4	750	8.1	40.0	9.4	1.5	20.3	6.9	2.6
50876	10A	3.4	620	7.2	29.5	4.0	1.1	13.3	5.4	1.4
51276	10A	3.6	520	6.3	27.0	5.4	1.2	13.3	7.0	3.0
51676	10A	3.6	0	6.4	29.3	7.0	1.2	13.3	5.0	1.9
51976	10A	3.5	0	10.0	30.1	5.8	1.3	22.0	6.3	0.0
52376	10A	3.7	0	6.0	16.8	5.3	0.0	14.0	8.8	0.0
62276	10A	3.3	400	7.8	14.5	8.5	1.3	12.5	5.5	8.1
62976	10A	3.0	1260	7.8	12.8	9.9	1.7	14.5	12.7	3.9
72876	10A	3.1	600	24.6	25.7	14.9	2.3	28.6	9.4	4.2
80376	10A	2.9	1500	33.8	53.7	92.0	5.4	44.6	0.6	2.1
80474	10B	3.2	700	8.3	18.0	1.3	2.3	0.0	0.0	0.0
81174	10B	3.3	700	8.7	17.8	1.5	2.6	0.0	0.0	0.0
81874	10B	3.3	700	8.7	18.0	0.8	2.7	0.0	0.0	0.0
82574	10B	3.3	675	5.1	11.7	0.8	2.1	21.8	14.8	2.3
100574	10B	0.0	0	7.3	12.7	0.8	2.2	0.0	0.0	2.6
110274	10B	0.0	560	7.1	10.9	0.9	2.6	0.0	0.0	0.0
52875	10B	3.1	0	19.3	48.3	2.7	2.5	28.6	16.2	2.4
60975	10B	3.6	450	8.8	43.3	8.8	0.9	12.2	0.7	0.0
70175	10B	3.1	420	8.6	14.8	21.9	0.6	18.4	12.1	0.0
80175	10B	3.1	675	11.5	29.6	2.9	2.4	18.5	22.3	0.0
31876	10B	3.5	460	6.0	14.7	2.2	1.5	23.7	26.0	0.0
40376	10B	3.7	520	4.0	10.4	1.6	1.0	13.7	21.0	0.0
40676	10B	3.8	740	8.3	22.5	15.5	2.7	69.8	19.1	3.9
41376	10B	3.4	800	9.9	42.2	7.1	2.2	71.3	15.5	2.7
41976	10B	3.5	925	9.6	47.5	11.2	2.6	32.5	31.3	9.4
42276	10B	3.4	950	9.8	47.5	0.5	2.7	33.8	29.1	4.8
42676	10B	3.5	900	9.3	55.0	11.4	2.9	32.5	35.4	6.3
42976	10B	3.4	900	10.7	115.0	10.0	2.9	42.5	15.5	3.3
50576	10B	3.8	560	6.8	39.8	4.6	1.3	18.8	15.8	2.6
50876	10B	4.1	420	5.6	27.8	9.9	1.0	14.0	7.3	1.3
52376	10B	4.0	0	4.7	16.5	3.8	0.9	10.0	8.3	0.0
72174	11	3.4	700	8.8	23.0	1.2	2.2	0.0	0.0	0.0
72874	11	3.2	650	11.3	21.4	1.4	2.5	24.7	19.0	2.4
80474	11	3.2	650	8.8	19.4	1.2	2.3	0.0	0.0	0.0
81174	11	3.2	700	8.7	18.2	1.6	2.4	0.0	0.0	0.0
81874	11	3.3	700	8.7	18.9	0.9	2.5	0.0	0.0	0.0
82574	11	3.4	650	5.0	12.4	0.8	2.1	23.0	17.0	2.3
100574	11	0.0	0	8.2	12.9	0.7	0.0	0.0	0.0	2.5
110274	11	0.0	600	7.1	11.3	0.5	1.9	0.0	0.0	0.0
60975	11	3.4	440	9.5	40.8	18.7	0.7	16.1	0.9	0.0
70175	11	3.4	420	6.8	26.2	0.5	1.4	18.6	10.5	0.0
80175	11	2.9	580	11.2	30.4	19.3	2.1	30.5	23.5	0.0
72876	11	3.2	400	20.0	20.0	9.6	2.2	26.1	14.9	5.1
61974	12	0.0	63	-0.1	-0.1	-0.1	-0.1	-0.4	6.5	0.8

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
72174	12	6.3	50	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
72874	12	6.3	50	-0.1	-0.1	-0.1	-0.1	-0.9	0.9	1.5
80474	12	6.1	50	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
81174	12	5.9	50	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
81874	12	6.2	65	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
60975	12	3.4	50	0.3	0.5	5.0	0.1	0.6	0.4	0.0
70175	12	4.8	50	-0.1	-0.1	0.4	-0.1	0.6	0.7	0.0
80175	12	6.4	50	-0.1	-0.1	-0.1	-0.1	0.5	0.9	0.0
72876	12	7.3	27	0.4	3.0	0.5	0.5	0.8	0.9	5.2
72174	13	3.3	800	11.5	36.0	1.8	3.0	0.0	0.0	0.0
72874	13	3.1	850	15.7	31.5	2.3	3.2	32.0	27.0	2.6
80474	13	3.1	850	12.2	28.5	2.5	3.2	0.0	0.0	0.0
81174	13	3.1	850	13.1	27.0	2.9	3.3	0.0	0.0	0.0
81874	13	3.2	800	12.2	27.8	1.3	3.9	0.0	0.0	0.0
82574	13	3.3	560	9.5	21.4	1.7	2.8	35.6	25.9	3.1
100574	13	0.0	0	14.1	21.2	1.1	3.0	0.0	0.0	3.0
110274	13	0.0	750	10.3	17.9	2.0	2.8	0.0	0.0	0.0
113074	13	0.0	0	8.0	0.6	12.0	1.7	25.0	20.0	2.6
70175	13	3.3	510	9.8	23.3	5.9	1.8	30.4	25.1	0.0
80175	13	3.0	900	18.6	26.9	21.8	3.5	29.7	32.3	0.0
72876	13	3.0	500	27.4	26.6	4.9	2.8	31.0	21.8	4.1
61974	14	0.0	245	1.5	7.0	-0.1	0.2	11.5	17.0	2.0
72174	14	3.4	450	3.6	14.2	0.1	0.6	0.0	0.0	0.0
72874	14	5.2	400	2.6	12.0	-0.1	0.9	24.8	45.0	2.5
80474	14	3.9	440	3.7	13.5	0.4	0.7	0.0	0.0	0.0
81174	14	4.9	500	4.0	12.8	-0.1	0.7	0.0	0.0	0.0
81874	14	5.1	600	2.6	12.9	-0.1	0.9	0.0	0.0	0.0
82574	14	4.9	550	4.0	12.4	-0.1	0.6	28.1	38.2	2.7
100574	14	0.0	0	0.3	14.1	0.1	0.7	0.0	0.0	2.9
110274	14	0.0	560	3.9	11.3	0.0	0.7	0.0	0.0	0.0
113074	14	0.0	0	2.9	9.2	0.7	0.5	22.0	35.0	2.1
61175	14	4.1	500	5.4	30.0	0.2	1.7	87.4	8.3	0.0
70175	14	3.8	320	1.9	11.0	0.8	0.4	21.7	30.4	0.0
80175	14	3.7	520	5.2	8.5	0.5	0.8	32.1	24.6	0.0
51976	14	3.6	0	16.4	62.0	5.4	2.3	34.0	17.6	0.0
72876	14	4.7	300	7.7	14.3	0.5	0.6	20.9	30.6	4.3
61974	15	0.0	2900	112.0	337.0	290.0	21.0	100.0	13.8	1.8
72174	15	3.0	2000	56.0	146.0	18.0	14.5	0.0	0.0	0.0
72874	15	2.9	1500	48.4	114.0	17.2	11.7	62.5	10.3	2.5
80474	15	2.9	1800	51.4	91.4	20.5	14.3	0.0	0.0	0.0
81174	15	3.0	1250	50.0	83.3	22.6	13.9	0.0	0.0	0.0
81874	15	2.9	1500	41.7	75.9	13.2	13.8	0.0	0.0	0.0
82574	15	3.0	1500	43.3	63.9	21.0	14.4	0.0	7.6	2.7
100574	15	0.0	0	40.7	27.2	27.6	10.1	0.0	0.0	2.7
110274	15	0.0	1300	32.2	29.8	57.9	8.4	0.0	0.0	0.0
113074	15	0.0	0	27.5	1.1	55.0	7.8	37.0	4.0	2.0
52875	15	3.0	0	15.6	56.0	11.1	2.9	14.5	3.8	1.7
60575	15	2.9	0	121.0	669.0	146.0	17.3	327.0	11.3	0.0
60975	15	2.9	1050	96.3	493.0	56.9	17.3	75.3	0.8	0.0
61875	15	2.7	0	108.0	334.0	92.3	18.6	77.4	11.1	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
70175	15	2.7	2000	34.3	193.0	51.9	21.8	91.9	15.9	0.0
80175	15	2.6	1700	64.7	75.0	66.3	19.5	74.4	11.9	0.0
31876	15	2.7	825	18.0	14.8	16.8	4.9	28.7	7.4	0.0
40376	15	3.0	1100	14.3	18.4	29.2	3.7	18.6	3.6	0.0
40676	15	3.2	1600	30.3	90.3	104.0	7.3	79.6	5.0	4.1
41376	15	2.7	1600	34.6	149.0	103.9	8.6	82.5	2.5	2.3
41976	15	2.8	0	32.2	125.0	95.2	10.1	63.0	6.8	6.3
42276	15	2.8	0	27.7	123.0	46.2	11.5	41.5	8.6	4.7
42976	15	2.7	0	29.3	47.5	71.9	9.0	32.5	7.6	3.7
50576	15	2.9	0	35.3	11.6	98.3	11.5	49.5	4.8	2.0
50876	15	2.7	0	22.0	337.0	150.0	11.6	61.0	4.3	1.5
51276	15	2.8	0	22.2	347.0	105.0	10.6	68.8	2.6	1.8
51476	15	2.9	0	21.6	353.0	72.5	10.6	57.0	2.6	1.8
60176	15	3.0	0	67.2	193.0	138.0	9.4	152.0	6.0	4.2
62976	15	2.9	0	62.5	100.0	125.0	13.8	97.0	20.0	3.7
72876	15	2.7	1200	85.3	80.8	84.1	11.4	65.6	7.6	4.8
80876	15	2.8	1400	29.7	74.3	229.0	12.8	61.8	10.5	2.6
81375	15	0.0	0	10.2	1.2	108.0	4.6	23.7	6.5	9.8
72174	16	6.2	210	0.4	-0.1	0.1	0.1	0.0	0.0	0.0
72874	16	6.1	200	-0.1	-0.1	-0.1	-0.1	8.0	12.0	2.4
80474	16	5.9	260	0.3	0.4	-0.1	-0.1	0.0	0.0	0.0
81174	16	5.9	250	0.7	0.3	-0.1	0.4	0.0	0.0	0.0
81874	16	6.0	300	-0.1	0.3	-0.1	-0.1	0.0	0.0	0.0
82574	16	5.9	310	1.0	-0.1	-0.1	-0.1	12.5	18.8	2.3
100574	16	0.0	0	0.2	-0.1	-0.1	0.2	0.0	0.0	2.4
110274	16	0.0	180	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
70175	16	4.6	50	-0.1	-0.1	-0.1	-0.1	0.9	0.8	0.0
80175	16	5.3	260	0.5	-0.1	-0.1	-0.1	12.2	16.3	0.0
72876	16	7.0	150	0.4	0.0	0.5	0.5	9.3	12.5	4.0
72174	17	3.8	2000	110.0	360.0	0.2	8.8	0.0	0.0	0.0
72874	17	3.9	2600	57.2	370.0	0.3	9.2	187.0	250.0	7.6
80474	17	3.5	2800	62.4	325.0	-0.1	14.8	0.0	0.0	0.0
81174	17	3.9	2600	74.7	334.0	-0.1	13.9	0.0	0.0	0.0
81874	17	4.1	2200	59.6	323.0	0.6	12.3	0.0	0.0	0.0
82574	17	4.1	3000	56.4	291.0	-0.1	15.7	-0.1	39.6	8.0
100574	17	0.0	0	52.5	39.6	0.2	10.1	0.0	0.0	9.3
110274	17	0.0	2200	3.4	289.0	-0.1	8.2	0.0	0.0	0.0
61375	17	3.9	1350	169.0	516.0	-0.1	5.0	142.0	7.0	0.0
70175	17	3.7	2600	49.4	256.6	2.4	9.7	185.2	261.9	0.0
80175	17	3.6	3000	90.1	359.0	0.4	12.1	221.0	371.0	0.0
51976	17	4.2	0	25.0	114.0	0.0	3.9	44.0	26.0	0.0
52376	17	4.3	0	27.5	130.0	0.0	22.5	158.0	89.5	0.0
62976	17	4.0	1800	100.0	231.0	1.4	9.5	220.0	220.0	10.0
72876	17	4.0	2700	102.0	390.0	1.1	10.1	184.2	219.0	9.3
61974	19	0.0	3840	625.0	1500.0	0.4	25.0	175.0	95.0	3.8
72174	19	3.7	5000	220.0	1810.0	0.1	32.0	0.0	0.0	0.0
72874	19	4.0	4500	229.0	1710.0	-0.1	35.7	201.0	125.0	5.0
80474	19	4.0	5500	245.0	1520.0	-0.1	35.8	0.0	0.0	0.0
81174	19	4.0	5000	223.0	1650.0	-0.1	37.4	0.0	0.0	0.0
81874	19	4.1	4500	226.0	1730.0	0.7	33.0	0.0	0.0	0.0

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
82574	19	4.0	5000	200.0	1560.0	-0.1	33.1	-0.1	39.6	5.1
100574	19	0.0	0	99.0	39.6	0.6	19.8	0.0	0.0	5.6
110274	19	0.0	4800	254.0	1770.0	1.0	34.9	0.0	0.0	0.0
61375	19	3.9	2000	212.0	1320.0	160.0	31.4	237.0	126.0	0.0
61875	19	3.6	0	144.0	1690.0	75.0	34.4	262.0	305.0	0.0
61975	19	3.8	0	136.0	1720.0	67.3	36.4	255.0	1.6	0.0
70175	19	3.5	5000	172.0	1740.0	1.6	75.0	322.0	287.0	0.0
80175	19	3.6	3500	325.0	2220.0	51.8	30.6	103.0	58.1	0.0
52476	19	4.6	0	56.8	306.0	6.4	11.1	70.0	5.8	0.0
60276	19	3.9	3500	214.0	1240.0	1.2	15.3	330.0	120.0	5.5
60376	19	3.9	3000	240.0	1050.0	0.3	24.2	439.0	148.0	5.3
61376	19	3.7	3550	260.0	1110.0	1.5	1.9	422.0	158.0	6.7
62276	19	3.9	3500	172.0	1400.0	2.8	26.5	247.0	87.5	5.5
62976	19	3.9	2700	205.0	1090.0	1.4	27.2	305.0	90.0	5.4
70176	19	3.9	3200	202.0	1770.0	3.8	30.8	267.0	102.0	7.0
70876	19	4.0	4200	205.0	847.0	1.9	29.5	273.0	67.5	5.9
71376	19	3.9	4300	212.0	1300.0	1.7	45.5	290.0	91.0	6.4
72376	19	3.9	4200	281.0	1580.0	1.9	0.0	0.1	0.0	0.0
72876	19	3.9	2600	109.0	866.0	1.0	32.3	241.0	96.7	7.4
80376	19	4.1	4500	313.0	1480.0	2.8	33.3	244.0	102.0	2.3
61974	20	0.0	0	112.0	237.0	200.0	23.0	100.0	15.5	3.4
72174	20	2.9	2000	100.0	148.0	20.0	22.1	0.0	0.0	0.0
72374	20	2.9	2400	79.3	128.0	20.0	24.0	100.0	1.1	4.0
80474	20	2.8	2400	78.1	106.0	20.5	23.8	0.0	0.0	0.0
81174	20	2.9	2300	87.9	113.0	35.2	23.9	0.0	0.0	0.0
81974	20	2.9	2200	63.7	92.2	26.8	19.2	0.0	0.0	0.0
82574	20	2.9	2400	59.7	82.5	21.9	19.9	0.0	15.3	3.8
100574	20	0.0	0	52.5	39.6	116.0	17.8	0.0	0.0	3.9
110274	20	0.0	2300	63.3	47.6	219.0	15.8	0.0	0.0	0.0
61375	20	3.1	1400	121.0	346.0	229.0	30.2	138.0	13.6	0.0
61875	20	12.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61975	20	12.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70175	20	2.7	2200	216.0	66.9	319.0	44.3	144.0	202.0	0.0
80175	20	0.0	0	105.0	190.0	51.8	30.6	103.0	58.1	0.0
80875	20	2.6	2000	83.0	106.0	71.0	52.2	60.7	86.3	0.0
72376	20	2.7	1400	102.0	96.5	243.0	19.4	90.3	13.8	5.4
72174	21	3.1	3750	136.0	940.0	3.7	25.8	0.0	0.0	0.0
72374	21	3.8	4000	166.0	1120.0	0.3	25.3	175.0	135.0	4.8
80474	21	3.9	2600	139.0	1300.0	0.4	28.1	0.0	0.0	0.0
81174	21	3.7	4000	188.0	1250.0	0.9	29.1	0.0	0.0	0.0
81874	21	3.9	3500	90.5	1260.0	0.7	27.1	0.0	0.0	0.0
82574	21	3.6	3200	134.0	1160.0	1.0	27.2	0.0	12.9	7.8
100574	21	0.0	0	62.4	39.6	1.7	19.8	0.0	0.0	5.0
110274	21	0.0	1500	174.0	1210.0	1.4	28.3	0.0	0.0	0.0
61375	21	3.7	1300	142.0	857.0	194.0	23.3	207.0	3.7	0.0
61875	21	4.1	0	50.8	807.0	92.3	28.8	230.0	439.0	0.0
70175	21	3.2	3900	137.0	740.0	120.0	30.1	234.0	112.0	0.0
72675	21	2.9	3500	127.0	1330.0	28.2	258.0	226.0	260.0	0.0
80175	21	2.9	3500	231.0	1090.0	7.7	30.6	208.0	170.0	0.0
80975	21	2.8	3750	189.0	1060.0	31.3	85.2	247.0	233.0	0.0

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
81475	21	3.0	3000	205.0	991.0	32.6	29.7	222.0	200.0	0.0
52476	21	3.8	0	85.0	327.0	10.6	19.7	60.0	35.0	0.0
52576	21	4.2	0	67.2	475.0	5.6	81.6	166.0	65.1	4.8
60276	21	3.4	2500	130.0	773.0	6.9	11.3	235.0	93.4	5.3
60876	21	3.2	2100	149.0	594.0	11.8	18.9	269.0	107.0	5.2
62276	21	3.1	2000	122.0	689.0	6.1	24.0	184.0	80.0	3.7
62876	21	3.1	2100	116.0	560.0	32.4	20.0	190.0	67.5	6.4
70176	21	2.9	2000	110.0	741.0	39.4	24.1	189.0	82.5	6.3
70876	21	3.1	3100	125.0	625.0	0.0	22.2	177.0	75.0	5.9
71476	21	3.2	2750	141.0	750.0	27.7	23.4	171.0	67.5	6.0
72376	21	3.1	3400	182.0	886.0	19.2	24.3	155.0	93.9	5.7
72876	21	2.9	2500	109.0	729.0	437.0	22.4	151.0	65.2	5.5
80376	21	3.1	3000	185.0	681.0	85.3	24.3	149.0	73.8	4.2
72174	22	3.2	900	12.0	15.0	0.8	4.6	0.0	0.0	0.0
72874	22	3.1	950	15.8	13.6	1.2	5.2	32.0	12.6	7.5
80474	22	3.1	1100	17.2	12.1	1.4	5.5	0.0	0.0	0.0
81174	22	3.2	850	18.2	14.5	2.1	6.2	0.0	0.0	0.0
81374	22	3.2	1000	15.6	12.4	1.7	5.3	0.0	0.0	0.0
82574	22	3.1	1100	16.8	12.7	2.0	6.1	0.0	12.9	7.8
100574	22	0.0	0	25.2	14.3	6.3	7.2	0.0	0.0	8.3
110274	22	0.0	1000	22.1	13.5	30.3	7.0	0.0	0.0	0.0
61375	22	3.2	700	25.4	20.6	142.0	7.4	80.1	11.4	0.0
61875	22	2.9	0	23.3	35.9	15.0	8.6	171.0	100.0	0.0
61975	22	2.9	0	19.0	28.7	15.0	8.9	164.0	92.3	0.0
70175	22	2.9	1100	28.8	12.3	20.3	5.9	39.4	156.0	0.0
72675	22	0.0	0	28.3	17.0	10.9	16.2	28.2	17.7	0.0
80175	22	2.8	1100	36.0	18.9	31.2	8.4	34.7	36.0	0.0
80875	22	0.0	0	29.4	19.0	21.6	49.9	21.7	45.0	0.0
81475	22	0.0	0	40.6	26.7	21.7	8.5	26.9	29.5	0.0
72376	22	2.9	600	44.7	16.1	40.5	6.6	42.2	11.4	10.3
72675	B1	0.0	0	97.1	860.0	10.7	27.4	124.0	133.0	0.0
80175	B1	3.0	2800	179.0	861.0	18.4	28.1	169.0	86.6	0.0
80375	B1	2.9	3500	169.0	922.0	18.4	26.6	203.0	200.0	0.0
81475	B1	3.0	2600	165.0	800.0	28.2	28.3	161.0	170.0	0.0
81475	B1A	3.2	2100	165.0	613.0	19.3	21.1	158.0	148.0	0.0
72675	B2	0.0	0	71.1	557.0	1.1	18.8	165.0	95.8	0.0
80175	B2	3.2	2200	108.0	500.0	4.9	20.4	115.0	92.3	0.0
80375	B2	3.2	2700	113.0	552.0	0.7	19.7	93.3	171.0	0.0
81475	B2	3.4	2000	87.8	592.0	6.2	20.2	110.0	105.5	0.0
72675	B3	0.0	0	63.4	489.0	1.1	17.1	108.0	39.7	0.0
80175	B3	3.3	2000	101.0	448.0	4.0	18.7	105.0	75.2	0.0
80875	B3	3.3	2200	95.2	512.0	0.6	18.9	75.6	113.0	0.0
81475	B3	3.4	2000	81.3	510.0	5.4	19.4	102.0	92.0	0.0
80175	B4	3.1	1000	86.8	379.0	4.5	16.5	92.8	80.9	0.0
80875	B4	3.4	2200	77.0	433.0	0.5	16.6	62.0	104.0	0.0
81475	B4	3.4	1800	78.5	450.0	3.9	17.1	86.3	79.7	0.0
71175	B5	0.0	0	73.0	40.2	0.9	10.2	93.5	359.0	0.0
80175	B5	3.5	1900	82.7	328.0	0.9	16.2	209.0	402.0	0.0
80875	B5	3.4	2200	65.5	409.0	0.8	16.8	56.7	91.2	0.0
81475	B5	3.3	1800	72.1	439.0	3.5	17.4	85.4	79.7	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
71175	B6	0.0	0	-0.1	-0.1	-0.1	-0.1	58.8	529.0	0.0
80175	B6	5.7	600	0.5	0.2	-0.1	-0.1	103.0	389.0	0.0
81475	B6A	5.6	600	0.8	0.3	-0.1	0.0	0.0	0.0	0.0
71175	B7	0.0	0	56.4	33.6	0.5	11.1	89.7	525.0	0.0
80175	B7	2.9	2200	75.3	332.0	4.7	13.3	217.0	397.0	0.0
80875	B7	3.4	2000	65.5	364.0	0.5	15.7	60.0	96.1	0.0
81475	B7	3.4	1800	65.6	426.0	1.7	16.6	83.8	84.5	0.0
70176	B1	3.2	1600	91.3	407.0	14.0	22.3	152.0	65.0	5.5
70876	B1	3.2	2500	87.5	342.0	230.0	20.5	85.0	65.0	5.2
71476	B1	3.4	2250	106.0	532.0	18.3	16.4	141.0	73.5	4.7
72376	B1	3.1	2400	150.0	661.0	16.6	19.6	134.0	84.7	7.9
72976	B1	3.1	2000	109.0	629.0	52.4	19.4	129.0	59.0	4.8
80376	B1	3.2	2500	161.0	572.0	58.3	20.2	133.0	70.9	3.7
70876	B1A	3.4	2000	67.5	272.0	210.0	16.3	115.0	62.5	6.3
71476	B1A	3.7	1950	83.5	411.0	5.5	13.8	124.0	55.5	5.6
72376	B1A	3.4	2200	117.0	572.0	6.2	15.0	110.0	78.7	5.5
72976	B1A	3.3	1900	109.0	541.0	22.0	0.0	115.0	55.5	5.3
80376	B1A	3.3	2200	130.0	529.0	23.6	17.4	117.0	67.1	4.6
70176	B2	3.4	1360	80.0	312.0	3.9	14.4	119.0	60.0	5.4
70876	B2	3.5	1900	67.5	272.0	50.7	15.3	112.0	60.0	5.4
71476	B2	3.7	1950	76.0	360.0	6.8	13.2	117.0	52.5	5.7
72376	B2	3.5	2000	110.0	529.0	6.5	14.7	105.0	68.0	6.2
72976	B2	3.3	1800	109.0	478.0	18.8	15.0	110.0	53.1	6.3
80376	B2	3.4	2100	123.0	465.0	19.5	15.8	112.0	62.4	4.4
70176	B3	3.5	1200	62.5	255.0	5.0	12.4	102.0	55.0	6.2
70876	B3	3.6	1840	50.0	232.0	50.5	14.0	107.0	60.0	7.4
71476	B3	3.5	1800	69.0	289.0	5.7	11.0	108.0	51.0	5.6
72376	B3	3.5	1800	95.7	396.0	4.5	13.3	96.3	64.3	5.8
72976	B3	3.3	1700	104.0	432.0	15.0	0.0	103.0	51.5	5.9
80376	B3	3.4	2000	117.0	441.0	16.0	14.7	102.0	59.5	4.5
70176	B4	3.1	1100	55.0	215.0	4.4	9.0	89.7	55.0	5.5
70876	B4	3.6	1630	49.5	230.0	40.4	12.0	110.0	60.0	5.6
71476	B4	3.7	1625	56.0	240.0	4.0	8.9	94.5	43.5	5.5
72376	B4	3.6	1450	77.2	371.0	3.1	11.1	85.2	57.7	5.5
72976	B4	3.4	1650	97.4	368.0	12.0	0.0	89.1	47.5	4.3
80376	B4	3.5	1700	98.5	366.8	12.9	12.0	90.1	57.7	4.0
70176	B5	3.5	1010	42.5	215.0	5.4	7.9	96.0	50.0	5.1
70876	B5	3.6	1660	32.5	227.0	20.5	11.6	110.0	55.0	6.0
71476	B5	3.6	1650	51.0	246.0	4.5	9.5	93.0	40.5	6.1
72376	B5	3.6	1500	72.9	355.0	3.4	10.9	81.5	54.8	5.0
72976	B5	3.4	1500	98.5	365.0	12.2	0.0	91.6	46.0	6.2
80376	B5	3.4	1700	95.7	369.0	11.5	11.7	92.6	54.0	4.1
70176	B7	3.6	960	43.0	182.0	1.9	7.9	93.7	62.5	4.8
72376	B6	7.1	500	8.9	0.1	0.5	0.0	20.0	99.0	4.5
80376	B6	6.9	600	0.2	0.1	0.5	0.0	21.6	96.9	3.5
70176	B7	3.6	960	43.0	182.5	1.9	7.9	93.7	62.5	4.8
70876	B7	3.7	1600	32.5	227.0	30.3	11.6	107.0	50.0	5.7
71476	B7	3.8	1525	51.0	270.0	4.0	8.3	99.0	40.5	5.1
72976	B7	3.4	1500	95.8	353.0	10.6	0.0	89.1	46.9	5.4
72376	B7	3.7	1600	75.8	353.0	2.5	10.3	80.3	57.7	5.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
80376	87	3.3	1700	88.6	349.0	10.3	11.7	85.2	54.0	4.6
61974	23	0.0	1200	34.0	137.0	1.8	4.4	50.0	52.5	3.1
72174	23	3.4	2000	72.0	400.0	0.6	9.9	0.0	0.0	0.0
72374	23	3.9	1500	61.0	326.0	0.3	13.8	32.1	75.0	4.4
80474	23	3.6	1700	68.6	442.0	0.0	14.8	0.0	0.0	0.0
81174	23	3.1	1500	74.7	473.0	-0.1	13.8	0.0	0.0	0.0
81874	23	3.9	2000	62.2	400.0	0.4	13.0	0.0	0.0	0.0
82574	23	3.8	1900	50.7	415.0	0.2	13.4	0.0	39.6	4.5
100574	23	0.0	0	50.9	39.6	0.1	13.3	0.0	0.0	4.9
110274	23	0.0	1600	72.4	368.0	0.6	12.1	0.0	0.0	0.0
61375	23	4.1	650	38.1	139.0	152.0	6.1	88.8	40.4	0.0
61875	23	0.0	0	12.1	194.0	0.8	5.7	56.5	322.0	0.0
70175	23	3.9	1200	55.9	182.0	1.1	5.6	84.7	70.3	0.0
71175	23	0.0	0	66.7	140.0	0.4	9.3	87.9	411.0	0.0
72675	23	0.0	0	42.3	389.0	0.7	24.6	89.3	72.9	0.0
80175	23	3.2	1700	90.1	332.0	1.3	13.6	86.5	77.7	0.0
81875	23	0.0	0	65.5	364.0	0.4	16.3	59.3	91.2	0.0
81475	23	0.0	0	65.6	417.0	1.3	16.6	86.3	84.5	0.0
52476	23	4.4	0	26.8	178.0	2.6	6.6	55.0	25.6	0.0
61276	23	4.4	1000	34.1	139.0	1.2	20.9	107.0	61.9	4.9
60876	23	4.4	750	30.0	118.0	1.1	3.5	105.0	79.8	4.1
62276	23	4.0	800	34.6	137.0	2.3	5.0	58.5	50.0	3.3
62976	23	3.8	940	32.5	160.0	2.2	5.8	78.5	42.5	5.1
70176	23	3.3	1100	35.0	187.0	3.8	7.8	72.5	57.5	4.7
70876	23	3.8	1580	32.5	225.0	2.2	11.7	117.0	42.5	5.9
71476	23	3.7	1595	51.0	259.0	2.6	8.9	99.0	40.5	5.0
72376	23	3.7	1500	70.1	352.0	2.2	10.0	81.5	56.7	5.6
72976	23	3.4	1750	94.2	352.0	9.6	0.0	37.9	45.1	5.2
80376	23	3.3	1600	87.1	356.0	8.9	11.1	82.7	54.8	4.4
110176	23	0.0	0	54.8	220.0	0.0	2.8	0.0	0.0	0.0
61974	24	0.0	700	14.0	67.0	0.2	1.8	30.0	52.0	3.1
72174	24	4.9	650	9.3	44.0	0.1	1.8	0.0	0.0	0.0
72874	24	5.2	600	8.8	35.5	0.4	1.6	25.0	57.0	3.8
80474	24	5.1	650	9.0	32.6	-0.1	1.6	0.0	0.0	0.0
81174	24	5.2	650	9.2	35.5	-0.1	1.7	0.0	0.0	0.0
81874	24	5.0	600	9.1	31.5	-0.1	1.1	0.0	0.0	0.0
82574	24	5.2	510	7.8	28.6	-0.1	1.7	28.3	39.6	4.1
110274	24	0.0	520	7.0	16.2	-0.1	1.0	0.0	0.0	0.0
123174	24	0.0	0	2.8	6.5	0.1	0.3	0.0	0.0	0.0
70175	24	4.6	700	17.6	33.0	0.5	1.6	38.2	48.3	0.0
80175	24	4.3	700	18.0	24.5	0.1	2.0	108.0	397.0	0.0
72976	24	5.1	450	20.2	34.6	0.5	0.5	23.8	38.9	4.6
80376	24	5.3	400	13.5	41.3	0.5	1.7	640.0	44.9	3.8
72174	25	7.1	140	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
72874	25	7.1	140	-0.1	-0.1	-0.1	-0.1	2.0	20.0	2.3
80474	25	6.6	150	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81174	25	6.8	150	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81874	25	6.9	150	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
82574	25	7.0	160	-0.1	-0.1	-0.1	-0.1	1.8	23.2	2.5
70175	25	5.3	100	0.0	0.0	0.3	1.0	1.6	12.8	0.0

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
80175	25	5.7	160	0.0	0.0	0.0	0.0	1.5	23.7	0.0
80376	25	7.8	100	0.1	0.1	0.5	0.0	1.7	22.2	2.5
61974	26	0.0	0	0.9	3.5	-0.1	-0.1	3.0	14.5	1.5
72174	26	6.8	200	1.3	4.4	-0.1	0.2	0.0	0.0	0.0
72874	26	7.0	210	1.1	3.5	-0.1	0.4	5.0	27.0	2.5
80474	26	6.6	210	1.1	2.1	0.0	0.3	0.0	0.0	0.0
81174	26	6.7	220	1.6	5.7	-0.1	0.5	0.0	0.0	0.0
81874	26	6.8	220	1.1	0.5	-0.1	-0.1	0.0	0.0	0.0
82574	26	6.9	230	1.3	1.2	-0.1	-0.1	5.4	27.1	2.7
70175	26	5.4	160	1.2	1.2	0.3	-0.1	4.1	19.0	0.0
80175	26	5.8	240	1.9	0.7	-0.1	0.3	6.3	30.1	0.0
80376	26	7.2	170	1.7	2.5	0.5	0.2	5.1	25.6	2.7
72174	27	6.5	50	0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
72874	27	6.8	60	-0.1	-0.1	-0.1	-0.1	1.0	7.0	2.6
80474	27	6.7	70	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81174	27	6.7	50	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
81874	27	6.9	75	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
82574	27	6.9	50	-0.1	-0.1	-0.1	-0.1	0.9	4.5	3.0
70175	27	5.5	50	-0.1	-0.1	0.1	0.3	0.3	4.0	0.0
80175	27	5.7	50	-0.1	-0.1	0.1	-0.1	0.5	2.0	0.0
80376	27	7.4	49	0.1	-0.1	0.5	-0.1	0.9	4.0	2.9
72174	28	3.9	75	0.2	0.8	0.1	-0.1	0.0	0.0	0.0
72874	28	6.8	80	0.5	0.4	0.0	-0.1	2.0	8.0	2.6
80474	28	6.6	65	0.4	0.5	0.0	-0.1	0.0	0.0	0.0
81174	28	6.4	70	0.6	0.4	0.0	-0.1	0.0	0.0	0.0
81874	28	6.4	70	-0.1	0.4	0.0	-0.1	0.0	0.0	0.0
82574	28	6.9	120	-0.1	0.7	0.0	-0.1	1.8	8.5	3.4
110274	28	0.0	0	0.1	0.2	0.5	-0.1	0.0	0.0	0.0
70175	28	5.3	55	-0.1	-0.1	0.2	0.1	0.9	0.6	0.0
80175	28	5.8	85	-0.1	0.3	-0.1	-0.1	1.4	6.6	0.0
41975	6802	3.0	0	14.5	14.4	21.2	7.0	55.8	31.0	0.0
32575	6803	0.0	0	0.7	-0.1	9.5	0.8	3.1	1.6	0.0
32575	6804	0.0	0	1.3	0.1	0.5	0.7	4.5	2.4	0.0
32575	6805	0.0	0	1.3	-0.1	10.4	0.9	4.8	4.1	0.0
32575	6806	0.0	0	1.4	-0.1	2.3	0.4	2.1	1.0	0.0
41975	6806	5.3	0	0.7	0.2	0.2	3.0	4.2	1.8	0.0
32575	6807	0.0	0	1.7	-0.1	2.9	0.5	2.9	1.5	0.0
32575	6808	0.0	0	1.4	0.0	2.8	0.4	2.1	1.0	0.0
32575	6809	0.0	0	0.7	-0.1	11.0	0.2	1.4	1.2	0.0
32575	6810	0.0	0	10.8	1.9	137.0	7.4	36.4	18.4	0.0
40976	6810	2.9	0	9.4	5.6	182.0	6.8	73.7	12.1	5.8
41576	6810	2.6	0	10.2	16.7	198.0	154.0	74.2	9.7	5.2
42476	6810	2.8	0	9.0	9.4	92.5	5.6	30.0	15.4	9.8
42876	6810	2.8	0	9.4	15.0	121.0	5.9	37.5	11.9	6.1
50476	6810	2.7	1650	14.0	77.5	345.0	5.4	28.8	5.1	5.1
50676	6810	2.8	1550	12.1	65.0	107.0	4.6	22.8	4.7	4.9
51176	6810	2.5	1500	11.7	87.3	75.0	4.6	22.5	2.6	4.0
51376	6810	2.8	1500	11.1	53.8	150.0	4.7	25.0	3.5	4.0
50176	6810	2.7	0	8.7	15.2	82.5	6.0	27.5	12.6	6.0
71576	6810	2.5	1500	18.0	6.3	317.0	11.6	50.0	13.5	8.2

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
73076	6810	2.9	1600	19.2	6.4	423.0	10.0	44.6	11.3	6.7
32575	6811	3.0	0	29.8	20.1	49.5	21.7	66.5	2.5	0.0
40976	6811	2.9	0	20.4	20.8	104.0	27.4	91.3	1.3	2.3
41576	6811	2.7	0	19.5	20.8	93.9	27.4	93.2	1.0	2.6
42476	6811	2.9	0	19.3	23.3	48.4	16.3	52.3	1.5	3.6
42376	6811	2.9	1350	22.2	26.1	60.0	21.9	62.5	2.4	2.8
50176	6811	2.9	0	19.2	20.7	55.0	17.5	57.5	2.0	3.0
50476	6811	3.0	1300	19.1	25.0	49.3	15.5	57.5	1.3	3.8
50676	6811	3.0	1300	20.2	21.0	53.1	15.0	52.5	2.0	3.0
51176	6811	2.8	1200	17.3	23.0	60.0	25.0	67.5	2.4	2.5
51376	6811	2.9	1350	16.4	23.0	51.5	22.5	67.5	2.6	2.7
71576	6811	2.5	1300	30.0	19.0	62.5	29.0	72.5	3.2	4.3
73076	6811	3.0	1200	29.2	23.3	65.1	24.0	69.2	1.6	2.3
41975	6812	4.3	0	0.7	0.4	0.2	3.0	4.6	1.7	0.0
41975	6813	2.9	0	28.6	37.1	87.7	38.4	118.3	4.4	0.0
41975	6814	2.7	0	33.4	316.4	311.8	91.9	216.8	5.9	0.0
50176	6814	6.8	0	1.1	0.0	11.0	0.2	37.5	1.4	4.3
50476	6814	7.0	100	0.5	0.0	7.9	0.3	1.2	0.9	4.5
50676	6814	6.6	120	1.0	0.0	6.3	0.3	1.1	2.2	4.8
51176	6814	6.2	95	0.6	0.0	5.4	0.2	1.1	0.9	4.8
51376	6814	6.5	110	0.6	0.1	7.8	0.2	31.3	0.6	4.5
41975	6815	3.7	0	0.9	0.2	0.2	3.0	2.7	1.5	0.0
32575	6816	0.0	0	2.0	-0.1	27.4	0.5	1.9	1.5	0.0
32575	6817	0.0	0	13.2	2.8	65.6	10.3	49.1	4.1	0.0
40976	6817	4.1	0	7.6	3.1	104.0	6.8	77.1	3.8	3.4
41576	6817	2.6	0	10.0	2.9	120.0	10.2	85.4	2.5	4.0
42476	6817	2.9	0	9.0	3.1	118.0	11.0	47.0	4.5	4.8
42976	6817	2.9	1400	9.7	3.3	55.3	10.4	50.0	4.5	4.3
50176	6817	2.8	0	9.3	2.7	106.0	11.0	77.5	3.8	4.2
50476	6817	2.9	1200	9.6	4.0	112.0	11.0	52.3	4.6	4.2
50676	6817	2.8	1700	1.6	14.2	6.5	1.9	3.5	0.7	4.4
51176	6817	2.6	1800	18.5	31.3	85.0	27.5	112.5	0.6	3.6
51376	6817	2.9	2200	18.1	34.5	85.0	26.3	109.0	0.5	3.7
71576	6817	2.8	1300	20.6	11.2	172.0	18.5	85.0	1.6	5.0
73076	6817	3.1	1200	20.1	11.4	187.0	17.2	71.7	1.1	3.6
73176	6817	3.1	1200	20.1	11.4	186.9	17.2	71.7	1.1	3.6
41975	6818	4.5	0	23.2	0.2	199.0	17.1	51.3	8.4	0.0
41975	6819	2.6	0	33.5	113.0	318.0	110.0	485.0	3.4	0.0
40976	6819	2.6	0	34.6	103.0	214.0	132.0	545.0	1.0	2.5
41576	6819	2.3	0	34.6	108.0	242.0	9.9	545.0	1.3	0.8
42476	6819	2.6	0	40.7	130.0	325.0	157.0	532.0	2.5	0.9
42876	6819	2.5	6000	40.2	17.5	42.5	172.0	545.0	2.4	0.5
41975	6820	5.1	0	1.3	0.2	0.7	3.0	2.8	2.3	0.0
41975	6821	5.0	0	1.4	0.2	0.0	3.0	3.0	1.6	0.0
41975	6822	4.1	0	8.6	1.5	101.0	14.4	52.3	5.6	0.0
32575	6823	0.0	0	17.0	8.3	63.2	7.5	33.3	3.7	0.0
40976	6823	2.9	0	10.2	5.7	169.0	5.3	71.8	1.0	4.4
41576	6823	2.7	0	11.1	6.5	185.0	6.0	71.3	1.0	5.4
42476	6823	2.9	0	9.6	7.3	55.0	6.5	29.3	2.8	5.8
42876	6823	2.9	1800	11.0	9.3	106.0	7.4	25.0	2.0	5.1

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
50176	6823	2.7	0	10.4	9.3	85.0	8.2	47.5	2.4	6.3
50476	6823	3.0	1400	10.1	13.8	175.0	6.7	30.0	2.7	6.3
50676	6823	3.0	1400	10.3	10.8	150.0	6.6	30.0	2.4	6.4
51176	6823	2.6	1550	11.1	8.5	200.0	7.3	27.5	3.4	6.3
51376	6823	2.9	1450	11.2	9.1	167.0	7.5	29.3	3.0	6.2
71576	6823	2.7	2750	49.3	90.0	757.0	19.4	97.5	1.0	6.8
73076	6823	3.0	2800	56.4	108.0	841.0	18.5	85.2	0.5	5.6
41975	6823A	4.7	0	1.2	0.2	25.3	3.0	2.7	1.3	0.0
41975	6823B	4.8	0	1.1	0.2	33.6	3.0	3.4	1.9	0.0
41975	6823C	4.9	0	1.6	0.2	1.8	3.0	2.7	1.3	2.3
41975	6823D	3.4	0	26.0	30.6	694.0	13.0	49.4	1.3	3.3
40976	6823D	2.9	0	13.0	4.4	237.0	10.0	81.0	15.3	6.0
41576	6823D	2.7	0	30.3	7.0	504.0	24.9	103.0	2.1	8.6
42876	6823D	3.6	1650	19.2	22.3	175.0	10.7	40.0	1.3	5.1
32575	6824	0.0	0	16.6	1.8	139.0	10.2	43.9	25.0	8.3
40976	6824	2.9	0	9.7	6.1	198.0	7.0	76.1	14.7	6.9
41576	6824	2.6	0	10.6	19.2	203.0	0.0	75.2	10.8	6.0
42476	6824	2.7	0	9.7	10.0	15.7	6.6	32.5	16.2	7.7
42876	6824	2.8	1600	10.4	16.6	775.0	6.0	6.5	15.6	6.0
50176	6824	2.7	0	9.8	17.3	117.0	6.3	33.7	12.6	6.4
50476	6824	2.7	1700	14.7	82.5	225.0	5.1	1.5	4.8	4.8
50676	6824	2.8	1600	11.2	55.0	75.0	4.6	32.7	3.0	4.6
51176	6824	2.5	1650	11.6	72.3	155.0	4.1	17.5	2.5	3.7
51376	6824	2.8	1550	15.3	35.7	218.0	5.8	46.8	3.8	0.0
51976	6824	2.8	0	15.3	25.9	256.0	5.2	22.0	5.3	0.0
52476	6824	2.7	0	12.8	22.0	334.0	7.9	36.0	8.8	0.0
71576	6824	2.6	1600	18.7	3.6	795.0	10.7	90.0	19.1	7.8
73076	6824	2.9	1700	18.7	35.7	481.0	10.3	44.6	15.2	7.1
32575	6825	0.0	0	3.0	0.2	147.0	3.8	16.6	10.8	8.7
52476	6825	4.5	0	3.0	0.0	218.0	5.3	22.0	9.4	0.0
71576	6825	4.2	825	3.6	0.0	202.0	5.7	15.0	5.7	7.6
73076	6825	4.9	700	3.7	0.3	229.0	4.5	20.2	5.9	7.2
32575	6826	0.0	0	0.7	-0.1	29.2	0.5	2.4	1.3	2.8
32575	6827	0.0	0	2.4	-0.1	125.0	3.4	14.8	10.8	8.2
40976	6827	7.0	0	2.4	0.2	138.0	3.7	64.9	10.0	6.4
41576	6827	6.5	0	1.9	-0.1	143.0	3.3	64.9	7.9	6.9
41576	6827	6.5	0	1.9	-0.1	143.1	3.3	64.9	7.9	6.9
42476	6827	5.7	0	1.8	0.0	120.0	3.6	14.8	24.8	8.0
42876	6827	6.2	850	1.7	0.0	157.0	3.9	2.5	14.8	6.1
50176	6827	6.2	0	1.6	0.0	155.0	3.5	15.0	12.3	7.6
50476	6827	6.7	800	2.1	0.0	162.0	3.5	15.0	11.6	7.7
50676	6827	6.6	750	1.9	0.0	115.0	3.6	17.5	12.0	7.6
51176	6827	4.8	800	2.0	0.0	157.0	3.9	14.0	8.6	7.7
51376	6827	6.0	750	2.0	0.0	152.0	3.9	16.0	9.0	7.4
51976	6827	6.5	0	1.5	0.0	0.0	3.5	20.0	6.4	0.0
52476	6827	6.7	0	2.7	0.0	214.0	4.7	20.0	8.4	0.0
52676	6827	6.4	0	1.7	0.6	164.0	3.3	33.1	8.5	13.2
71576	6827	6.2	790	2.4	0.0	202.0	4.9	12.5	4.7	7.4
73076	6827	6.3	650	3.0	0.1	222.0	4.2	17.6	4.7	7.3
32575	6828	0.0	0	71.0	2.4	1890.0	29.3	124.0	110.0	19.4

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
40976	6828	2.7	0	34.7	4.0	2600.0	29.9	121.0	114.0	8.6
41576	6828	2.4	0	34.6	2.5	2600.0	34.9	145.0	45.8	9.0
42476	6828	2.7	0	37.4	2.6	330.0	27.5	144.0	15.7	11.1
42876	6828	2.7	4500	34.4	2.5	135.0	32.5	142.0	74.3	10.0
32575	6829	0.0	0	33.2	0.8	65.0	25.0	101.0	110.0	8.3
41975	6829	2.5	0	25.1	1.1	684.0	25.1	108.0	73.6	6.8
40776	0829	2.7	0	24.3	4.4	491.0	29.9	112.0	56.5	8.2
41576	6829	2.5	0	21.8	0.9	553.0	27.4	111.0	52.1	6.3
42476	6829	2.7	0	21.7	1.0	180.0	18.2	83.3	77.4	7.8
42876	6829	2.7	3000	25.0	1.1	132.0	25.0	95.0	80.9	7.2
50176	6829	2.7	0	22.3	1.9	14.1	22.5	95.0	75.6	7.7
50476	6829	2.7	3250	21.4	1.4	756.0	18.0	87.5	70.5	7.7
50676	6829	2.7	3600	23.7	1.1	52.0	0.8	90.0	75.0	7.0
51176	6829	2.5	3000	18.7	26.3	750.0	26.3	96.3	56.0	6.8
51376	6829	2.7	3500	41.0	0.7	820.0	27.4	219.0	131.0	0.0
81376	6829	0.0	0	33.5	1.2	907.0	25.1	90.1	83.6	9.2
32575	6830	0.0	0	9.9	1.4	95.2	5.8	30.1	14.3	7.4
40776	6830	2.8	0	5.8	7.0	104.0	3.4	64.9	7.0	3.3
41576	6831	2.6	0	8.3	10.7	-0.1	4.3	67.9	7.0	4.8
42476	6830	2.8	0	9.2	10.5	95.0	5.6	30.0	9.7	5.6
42876	6830	2.8	1350	9.4	15.5	164.0	5.5	25.0	8.8	5.1
50176	6830	2.7	0	8.8	12.0	93.2	4.8	22.5	9.4	4.9
50476	6830	2.9	1100	9.3	22.5	76.2	3.6	20.4	4.8	4.2
50676	6831	2.9	1300	8.0	19.4	90.0	3.5	20.2	5.0	4.3
51176	6830	2.6	1200	9.0	32.0	75.0	4.0	19.3	4.2	3.4
51376	6830	2.8	950	9.3	30.8	85.0	4.3	18.3	4.7	4.0
32575	6831	0.0	0	22.6	3.3	53.9	13.0	61.0	45.4	8.3
32575	6832	0.0	0	1.8	0.0	99.2	3.2	12.8	5.7	5.4
32575	6833	0.0	0	17.3	1.3	412.0	9.4	44.4	14.9	6.6
32575	6834	0.0	0	7.8	-0.1	306.0	4.9	23.7	17.0	14.8
32575	6835	0.0	0	3.2	1.3	4.2	1.3	6.9	2.0	2.7
41975	6836	3.2	0	3.7	2.0	3.6	3.0	8.4	4.0	2.2
41975	6837	2.8	0	32.8	75.5	410.0	25.8	118.0	2.9	1.9
41975	6838	4.5	0	0.6	0.2	10.0	0.1	1.4	1.2	2.5
41975	6839	3.3	0	3.2	0.4	4.9	3.0	4.7	2.2	2.1
41975	6840	3.0	0	5.0	0.3	7.0	3.0	7.1	2.5	2.8
41975	6841	3.5	0	2.4	0.5	0.2	3.0	3.7	1.4	1.7
41975	6842	5.0	0	1.2	0.2	15.5	0.1	1.8	1.2	1.5
41975	6843	4.8	0	6.0	0.2	6.9	3.0	5.0	2.3	2.0
41975	6844	4.5	0	1.8	0.2	0.3	3.0	1.5	1.0	2.8
41576	68291	2.5	0	21.8	0.9	553.3	27.4	111.7	52.1	6.3
41975	68400	2.7	0	33.4	316.0	312.0	91.9	217.0	5.9	0.0
50176	68535	2.4	0	9.1	18.8	92.5	3.3	20.0	11.9	3.3
50476	68535	2.3	0	0.0	31.7	472.0	4.7	35.0	1.1	2.9
50676	68535	2.6	2800	28.7	460.0	497.0	3.3	22.5	0.3	3.0
51176	68535	2.6	1800	13.9	122.0	310.0	2.9	15.0	0.5	2.6
51376	68535	2.7	1800	8.6	44.0	52.5	2.7	16.0	2.5	3.1
51976	68535	2.8	0	18.3	57.0	423.0	2.1	21.0	2.3	0.0
52476	68535	2.6	0	20.5	6.6	692.0	7.6	36.0	5.7	0.0
52676	68535	2.5	0	35.2	73.5	699.0	7.8	82.5	8.5	5.3

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
73076	68535	2.7	5900	56.4	26.0	3810.0	31.1	136.0	53.1	5.3
81376	68535	0.0	0	56.4	30.8	3840.0	33.9	149.0	134.0	8.9
40976	68616	2.8	0	8.7	26.0	104.0	3.9	66.9	7.4	4.7
41576	68616	2.6	0	8.4	26.0	104.0	2.6	64.0	1.6	3.2
41576	68616	2.6	0	8.4	26.0	104.0	2.6	64.0	1.6	3.2
42476	68616	2.8	0	10.7	22.5	100.0	4.3	13.8	3.6	3.5
42376	68616	2.7	1200	9.3	26.2	55.5	4.2	2.3	4.4	3.5
50176	68616	2.8	0	9.1	18.8	92.5	3.3	20.0	11.9	3.3
50476	68616	2.9	1000	8.0	32.5	63.8	2.6	15.3	2.1	3.0
50676	68616	2.9	1100	7.0	32.5	57.5	0.7	12.5	1.3	3.0
51176	68616	2.7	1100	8.7	41.3	65.0	2.6	13.0	2.6	2.6
51376	68616	2.9	1000	8.6	44.0	52.5	2.7	16.0	2.5	3.1
51976	68616	2.9	0	14.0	26.2	136.0	4.1	22.0	4.2	0.0
52476	68616	2.9	0	8.0	19.7	104.0	3.6	20.0	3.7	0.0
52676	68616	2.4	0	10.0	18.4	29.1	5.9	40.4	5.1	3.3
71576	68616	2.6	1900	26.0	4.8	287.0	12.0	52.5	19.2	5.9
73076	68616	2.8	1850	27.7	6.0	547.0	14.1	56.9	22.8	5.5
81376	68616	0.0	0	30.5	136.0	632.0	14.7	61.8	51.2	10.6
73076	68689	2.7	1400	14.7	0.8	47.6	7.8	37.2	23.1	1.0
81376	68689	0.0	0	16.9	0.7	222.0	7.8	36.0	23.9	8.8
41975	7002	2.5	0	28.0	2.0	1080.0	30.5	215.0	113.0	21.6
41975	7003	2.5	0	29.6	1.5	1050.0	38.4	209.0	78.3	12.2
41975	7004	2.5	0	28.2	1.8	798.0	36.7	178.0	74.1	17.5
41975	7005	2.5	0	33.8	2.5	1650.0	63.3	317.0	95.2	39.6
41975	7006	2.4	0	28.3	2.4	873.0	38.5	192.0	79.7	17.3
41975	7007	2.6	0	12.4	3.1	70.4	7.5	35.8	14.2	8.9
41975	7008	2.4	0	33.3	9.0	451.0	61.8	262.0	131.0	10.3
41975	7009	2.6	0	24.4	3.0	267.0	13.9	60.6	42.0	8.4
41975	7010	2.4	0	31.5	6.6	1830.0	38.6	202.0	73.2	10.0
41975	7011	2.3	0	30.0	11.8	698.0	31.2	109.0	58.4	9.6
41975	7012	2.7	0	3.9	0.8	21.2	3.0	12.9	6.1	3.5
41975	7013	4.5	0	1.3	0.2	0.6	3.0	2.0	1.1	1.9
52375	7101	2.4	0	66.7	283.0	1390.0	5.0	17.0	0.1	1.8
61475	7101	2.6	0	45.7	177.0	318.0	1.2	25.4	16.5	0.0
52375	7102	2.4	0	60.8	180.0	1020.0	2.1	12.9	0.5	3.7
61475	7102	2.7	0	50.9	180.0	123.0	0.6	14.4	15.8	0.0
52375	7103	2.1	0	67.7	465.0	1390.0	6.9	43.4	0.6	2.1
61475	7103	2.6	0	50.9	128.0	292.0	0.6	27.3	11.0	0.0
52875	7104	2.3	0	63.0	446.0	1390.0	9.1	35.0	2.1	3.8
61475	7104	2.7	0	45.7	158.0	354.0	1.7	14.9	40.4	0.0
52375	7105	2.3	0	56.0	462.0	1390.0	2.5	18.3	0.2	1.9
61475	7105	2.6	0	45.7	169.0	372.0	0.5	16.0	3.6	0.0
52875	7106	2.3	0	60.8	477.0	0.5	7.3	32.0	1.8	3.0
61475	7106	2.8	0	80.6	71.0	157.0	1.3	20.3	24.0	0.0
52375	7107	2.3	0	60.6	483.0	1390.0	5.9	29.9	1.0	2.3
61475	7107	2.6	0	95.7	118.0	1170.0	6.5	46.1	81.8	0.0
52875	7108	2.4	0	63.2	498.0	1060.0	6.2	23.0	0.7	2.0
61475	7108	3.0	0	57.4	80.5	505.0	4.5	32.6	12.8	0.0
52875	7109	2.7	0	33.8	56.0	47.9	5.7	24.9	6.3	3.2
61475	7109	2.9	0	57.4	38.1	3.9	1.8	21.6	49.1	0.0

DATE	STA	PH	EC	CD	CU	FE	MN	MG	CA	NA
52875	7110	2.4	0	64.5	462.0	1180.0	9.9	32.8	0.6	1.8
61475	7111	2.5	0	50.9	35.1	328.0	9.5	48.6	169.0	0.0
61475	7112	2.2	0	315.0	1670.0	3680.0	5.6	72.2	9.2	0.0
61475	7113	2.4	0	50.9	356.0	1920.0	10.4	83.4	20.8	0.0
61475	7114	2.8	0	33.9	44.6	21.3	0.5	7.6	4.3	0.0
81376	71544	0.0	0	16.6	5.2	171.0	7.0	33.5	18.9	7.9
52875	7401	2.8	0	58.9	236.0	127.0	9.9	45.3	6.8	1.5
72675	7201A	2.7	0	13.5	1.3	0.6	6.3	19.3	9.3	0.0
72675	7232	2.6	0	11.9	0.9	1.3	15.5	28.2	26.3	0.0
72675	7203	2.7	0	16.3	0.7	1.1	15.4	26.4	27.9	0.0
72676	7301	2.8	0	18.6	15.9	19.4	4.1	11.0	5.6	0.0
72675	73679	2.8	0	21.4	15.6	0.6	4.1	9.7	4.4	0.0
72675	73706	4.7	0	0.0	0.0	0.0	0.0	0.8	3.6	0.0
52875	7401	2.8	0	58.9	236.0	126.6	9.9	45.3	6.8	1.5
61875	7401	2.7	0	108.2	334.5	92.3	18.6	77.4	11.1	0.0
52875	7402	3.4	0	0.6	0.2	0.4	0.9	2.6	1.8	2.0
52875	7403	2.8	0	58.9	236.0	139.0	9.9	45.5	7.0	1.6
61875	7404	4.9	0	1.1	0.2	0.3	1.3	1.6	2.9	0.0
52875	7404	5.7	0	1.3	0.2	0.4	0.6	2.7	2.7	3.0
61875	7405	2.8	0	166.0	508.0	142.0	25.0	194.0	26.8	0.0
52875	7405	2.7	0	62.4	321.0	198.0	9.9	58.7	1.2	1.2
61875	7406	2.8	0	114.0	391.0	127.0	50.0	153.0	25.6	0.0
61875	7407	4.4	0	144.0	105.0	2820.0	33.4	269.0	100.0	0.0
61875	7408	2.9	0	121.0	530.0	359.0	12.1	82.2	9.1	0.0
61875	7409	2.9	0	348.0	456.0	359.0	33.4	144.0	24.5	0.0
61875	7410	3.2	0	473.0	778.0	110.0	34.6	163.0	17.2	0.0
61875	7411	2.8	0	348.0	4.2	117.0	10.4	27.6	14.6	0.0
61875	7412	2.9	0	174.0	420.0	169.0	32.9	126.0	22.9	0.0
61875	7413	0.0	0	0.6	4.0	4.6	0.6	0.0	19.0	0.0
61375	74690	2.8	0	85.2	500.0	42.3	2.8	8.1	0.3	0.0
61875	74810	2.8	0	834.0	3050.0	953.0	276.0	565.0	26.3	0.0
61375	74860	3.2	0	472.6	778.0	109.6	34.6	163.2	17.2	0.0
62176	DH 1	3.3	980	13.5	-0.1	90.0	4.4	22.0	55.0	19.0
62976	DH 1	3.2	800	12.0	0.7	282.0	3.7	38.0	185.0	42.5
71776	DH 1	3.0	800	11.4	1.0	5.0	4.8	20.3	62.5	20.0
71276	DH 1	3.0	950	9.0	2.5	1120.0	4.4	22.5	57.5	17.5
72076	DH 1	3.0	1000	14.9	1.9	117.0	4.7	23.8	63.3	15.1
72776	DH 1	2.9	1100	26.6	2.3	84.0	4.1	26.1	55.5	14.0
80376	DH 1	3.2	1000	14.6	1.3	4.8	4.6	25.1	66.1	10.1
62176	DH 2	4.6	1170	1.3	-0.1	117.0	1.5	9.5	152.0	27.5
62976	DH 2	3.7	1150	3.1	1.2	20.5	1.5	12.5	137.0	37.5
70776	DH 2	4.0	890	-0.1	1.3	175.0	1.6	11.2	130.0	25.0
71376	DH 2	4.2	1170	1.3	1.0	160.0	1.0	10.0	125.0	22.5
72076	DH 2	3.4	1100	0.4	1.9	84.1	1.4	11.3	127.0	19.8
72776	DH 2	4.0	1200	0.4	1.1	84.1	1.4	11.6	115.0	17.9
80376	DH 2	4.1	1100	0.7	1.6	5.6	1.7	13.5	137.0	17.4
62276	DH 3S	4.3	640	17.8	31.5	5.9	24.0	15.3	9.0	9.0
62976	DH 3S	4.0	810	36.0	45.0	6.0	30.0	39.3	3.5	12.5
70776	DH 3S	4.0	650	37.6	45.0	5.0	32.5	17.5	2.1	7.4
71376	DH 3S	3.9	1180	39.7	60.0	6.9	45.0	50.0	2.6	12.5

DATE	STA	PH	EC	CO	CU	FE	MN	MG	CA	NA
72076	DH 3S	3.9	1000	78.1	88.6	5.8	66.4	43.4	1.7	10.5
72776	DH 3S	3.7	1100	68.6	87.4	4.2	71.7	40.9	1.2	11.5
80376	DH 3S	3.8	1200	75.8	90.8	4.2	80.5	43.4	1.8	7.4
62276	DH 3D	7.0	245	-0.1	-0.1	3.3	1.5	30.5	33.7	8.7
62976	DH 3D	7.0	175	-0.1	0.2	4.8	0.5	4.6	33.0	9.5
70776	DH 3D	6.9	195	1.5	-0.1	4.1	0.8	4.0	37.2	7.2
71376	DH 3D	6.3	270	0.8	0.3	3.6	0.9	5.0	52.5	10.0
72076	DH 3D	5.7	310	-0.1	4.9	3.4	5.3	6.0	1.4	8.7
72776	DH 3D	5.3	300	7.4	4.8	5.4	5.0	0.6	31.2	8.2
80376	DH 3D	5.3	300	5.8	5.3	5.6	6.5	7.7	44.9	6.8
62276	DH 4	6.0	260	-0.1	-0.1	-0.1	0.7	50.0	30.0	20.0
62976	DH 4	5.8	300	3.7	-0.1	-0.1	0.7	6.3	50.0	20.0
71376	DH 4	5.2	520	3.4	0.8	9.6	1.7	12.5	77.5	17.5
72076	DH 4	5.6	550	6.6	0.9	13.2	2.8	18.4	76.7	14.8
72776	DH 4	5.2	450	11.1	1.3	15.5	3.1	20.6	65.4	13.0
80376	DH 4	5.5	500	10.4	1.8	27.9	4.6	30.8	64.3	10.8
62276	DH 5	4.4	2400	157.0	862.0	9.1	26.4	212.0	117.0	10.0
62976	DH 5	4.1	2600	200.0	425.0	8.4	26.0	167.0	45.0	10.0
70376	DH 5	4.3	3400	1470.0	620.0	14.8	27.7	258.0	75.0	15.0
71376	DH 5	4.2	3000	237.0	772.0	11.7	29.5	264.0	62.5	12.5
72076	DH 5	4.4	3000	109.0	866.0	12.3	26.5	182.0	89.0	9.3
72776	DH 5	4.1	3250	228.0	1070.0	6.2	28.7	189.0	102.0	8.8
80376	DH 5	4.2	3200	228.0	1020.0	0.0	1.1	181.0	109.0	6.2
70776	DH 6	3.9	6000	507.0	9.2	3980.0	70.0	545.0	110.0	15.0
71376	DH 6	3.8	5500	270.0	2.8	2670.0	62.0	483.0	52.5	17.5
72076	DH 6	3.8	4000	235.0	7.8	1490.0	39.4	299.0	186.0	17.3
72776	DH 6	4.1	3000	147.0	4.3	783.0	24.3	268.0	200.0	17.1
80376	DH 6	4.4	2900	110.0	1.9	0.0	19.6	256.0	210.0	14.6
80476	TP37	5.8	2000	33.1	0.2	4.5	0.8	106.0	369.0	8.2
60475	100	4.7	420	8.2	1.8	21.1	3.5	158.0	569.0	0.0
61175	100	4.6	1050	5.9	0.8	41.1	5.0	67.2	38.1	0.0
70175	100	4.9	800	5.8	1.4	32.5	5.5	20.8	96.6	0.0
60474	101	3.1	875	9.5	2.2	23.1	3.2	161.0	405.0	0.0
61175	101	3.2	910	8.0	1.4	63.4	5.9	74.8	25.4	0.0
70175	101	3.0	1100	4.5	3.4	18.0	4.5	19.0	141.0	0.0
60475	102	3.6	115	1.7	5.8	0.4	0.0	3.4	4.0	0.0
70175	102	3.9	200	3.4	9.5	0.6	1.0	7.7	3.4	0.0
61175	103	5.2	50	0.2	0.0	0.8	0.1	1.0	0.0	0.0
61175	104	4.9	50	0.0	0.0	1.5	0.0	1.0	0.0	0.0
61175	105	5.2	70	0.7	0.2	1.3	0.0	2.4	0.3	0.0
61175	106	3.3	700	23.1	43.0	0.8	5.8	67.9	0.4	0.0
61175	107	3.4	500	20.2	28.0	40.0	2.0	16.6	1.9	0.0
61175	108	4.6	50	0.8	0.0	1.8	2.0	1.5	1.3	0.0
61375	109	4.9	100	1.9	4.9	1.5	0.8	9.6	7.7	0.0
61375	110	4.6	190	5.0	20.6	1.8	0.8	8.1	10.0	0.0

Appendix III-2. Blackbird Creek drainage discharge data for 1974, 1975 and 1976. Discharge of Stations 4 and 6 is given in cubic feet per second (cfs). Discharge at all other stations is given in gallons per minute (gpm).

Date	Flow		Date	Flow	Date	Flow
Station 4 (Blackbird Creek)			Station 4 (Blackbird Creek)		Station 4 (Blackbird Creek)	
7-21-74[a]	2.2		4-05-76[a]	7.4	6-05-76[a]	24.8
7-28	2.2		4-06	9.9	6-06	24.2
8-11	2.0		4-07	14.1	6-07	24.2
8-18	1.8		4-08	15.2	6-08	24.2
8-25	1.8		4-09	11.1	6-09	23.5
		6-day Ave.	4-10	11.6	6-10	26.7
5-31-75[a]	16.6	16.6	4-11	15.2	6-11	26.7
6-02	34.4		4-12	14.7	6-12	23.5
6-03	34.4		4-13	12.1	6-13	21.8
6-04	30.5		4-14	11.6	6-14	19.4
6-05	36.4		4-15	9.0	6-15	17.9
6-06	39.3	35.0	4-16	7.6	6-16	15.7
6-07	39.3		4-17	6.0	6-17	14.9
6-09	30.5		4-18	5.8	6-18	13.9
6-10	27.9		4-19	4.8	6-19	13.7
6-11	20.9		4-20	4.0	6-20	13.6
6-12	30.2	29.8	4-21	4.8	6-21	14.9
6-13	31.8		4-22	7.8	6-22	13.9
6-14	32.5		4-23	4.8	6-23	12.8
6-15	31.3		4-24	7.8	6-24	11.6
6-17	27.2		4-25	6.2	6-25	10.4
6-18	23.3	29.2	4-26	5.8	6-26	9.5
6-19	26.5		4-27	4.5	6-27	8.0
6-20	32.5		4-28	4.3	6-28	7.8
6-24	20.5	26.5	4-29	4.7	6-29	7.4
7-01	11.1		4-30	7.8	6-30	7.2
7-03	11.6	11.4	5-01	12.8	7-01	7.0
7-08	10.0		5-02	14.4	7-02	6.8
7-10	10.0		5-03	18.2	7-03	6.2
7-11	7.2	9.1	5-04	19.1	7-04	5.8
7-28	3.4		5-05	18.5	7-05	5.4
7-29	3.4		5-06	16.0	7-06	5.0
7-30	10.5		5-07	22.1	7-07	4.7
7-31	4.0	5.3	5-08	25.1	7-08	4.5
8-01	4.0		5-09	28.4	7-09	4.1
8-02	3.5		5-10	33	7-10	4.1
8-03	3.5		5-11	38	7-11	4.0
8-04	3.3		5-12	35	7-12	4.3
8-05	3.3		5-13	35	7-13	4.3
8-06	3.1	3.5	5-14	39	7-14	4.0
8-07	3.1		5-15	33	7-15	3.8
8-08	2.9	3.0	5-16	28	7-16	3.8
			5-17	39	7-17	3.8
3-18-76[a]	2.8		5-18	40	7-18	4.3
3-19	1.8		5-19	38	7-19	4.3
3-20	1.7		5-20	35	7-20	3.8
3-21	1.7		5-21	33	7-21	3.6
3-22	1.5		5-22	31	7-22	3.5
3-23	1.3		5-23	30.0	7-23	3.6
3-24	1.3		5-24	38.7	7-24	3.8
3-25	1.5		5-25	45.1	7-25	3.8
3-26	1.1		5-26	40.9	7-26	
3-27	1.1		5-27	41.3	7-27	
3-28	0.8		5-28	42.8	7-28	3.6
3-29	0.8		5-29	38.7	7-29	3.5
3-30	1.0		5-30	34.1	7-30	3.5
3-31	2.0		5-31	31.7	8-01	
4-01	1.7		6-01	30.3	8-02	
4-02	1.7		6-02	29.0	8-03	
4-03	2.7		6-03	28.0	8-04	3.8
4-04	5.2		6-04	26.4	8-05	3.8

Appendix III-2. (cont.)

Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow
Station 4 (Blackbird Creek)		Station 7 (6850' Portal)		Station 7 (6850' Portal)		Station 7 (6850' Portal)		Station 7 (6850' Portal)	
8-09-76[a]	3.8	8-18-74	30	6-15-75[a]	120	9-04-75[a]	38	5-15	146
8-10	3.8	8-25	60	6-16	116	9-05	41	5-16	146
8-11	3.8	10-05	40	6-17	111	9-06	41	5-17	129
8-12		11-02	22	6-18	107	9-07	41	5-18	120
8-13		11-30	18	6-19	103	9-08	41	5-19	120
8-14		12-31	4	6-20	103	9-09	41	5-20	111
8-15	4.0			6-21	103	9-10	41	5-21	107
8-16	4.3	4-19-75[a]	10	7-03	65	9-11	41	5-22	107
8-17	4.3	4-20	10	7-04	65	9-12	41	5-23	103
8-18	4.1	4-21	11	7-05	65	9-13	41	5-24	99
8-19	5.4	4-22	13	7-06	65	9-14	41	5-25	99
8-20	4.7	4-23	16	7-07	61			5-26	91
8-21	4.3	4-24	18	7-08	61	3-18-76[a]	39	5-27	91
8-22	4.3	4-25	19	7-09	61	3-19	39	5-28	87
8-23	4.8	4-26	18	7-10	58	3-20	39	5-29	87
8-24	4.7	4-27	16	7-11	58	3-21	39	5-30	83
8-25	4.3	4-28	14	7-12	58	3-22	39	5-31	83
8-26	4.3	4-29	14	7-13	58	3-23	39	6-01	83
8-27	4.1	4-30	14	7-14	55	3-24	39	6-02	83
8-28	4.0	5-01	16	7-15	55	3-25	39	6-03	80
8-29	3.8	5-02	16	7-16	55	3-26	39	6-04	80
8-30	3.8	5-03	18	7-17	51	3-27	39	6-05	80
8-30	3.8	5-04	16	7-18	51	3-28	39	6-07	80
9-01	2.3	5-05	16	7-19	51	3-29	39	6-08	80
9-02	1.6	5-06	14	7-20	51	3-30	39	6-09	80
9-03	3.5	5-07	10	7-21	49	3-31	39	6-10	80
9-04	3.5	5-08	8	7-22	49	4-01	39	6-11	80
9-05	3.5	5-09	6	7-23	49	4-02	39	6-12	80
9-06	3.6	5-10	6	7-24	49	4-04	39	6-13	80
9-07	4.0	5-11	8	7-25	59	4-05	39	6-14	80
9-08	3.8	5-12	6	7-26	49	4-06	39	6-15	80
9-09	3.6	5-13	8	7-27	45	4-13	39	6-16	80
		5-14	14	7-28	45	4-14	39	6-17	80
Station 6 (Blackbird Creek)		5-15	28	7-29	45	4-15	45	6-18	80
		5-16	38	7-30	45	4-16	45	6-19	80
5-20-76	25.4	5-17	55	7-31	45	4-17	45	6-20	80
5-21	22.4	5-18	60	8-01	45	4-18	45	6-21	76
5-22		5-19	65	8-02	45	4-19	39	6-22	76
5-23		5-20	65	8-11	45	4-20	39	6-23	72
5-24	30.2	5-21	65	8-12	45	4-21	39	6-24	72
5-25	32.8	5-22	65	8-13	45	4-22	45	6-25	72
5-27	31.9	5-23	58	8-14	45	4-23	45	6-26	72
5-29	30.4	5-24	58	8-14	45	4-24	45	6-27	69
5-31	25.9	5-25	52	8-15	45	4-25	45	6-28	69
6-02	24.4	5-26	52	8-16	45	4-26	52	6-29	65
6-03	25.1	5-27	45	8-17	45	4-27	52	6-29	65
6-06	19.3	5-28	45	8-18	45	4-28	52	7-01	65
6-07	19.7	5-29	45	8-19	45	4-29	45	7-02	65
6-09	19.8	5-30	48	8-20	45	4-30	45	7-03	65
6-11	21.3	5-31	58	8-21	45	5-01	52	7-04	62
6-17	11.4	6-01	65	8-22	41	5-02	58	7-05	62
6-18	10.8	6-02	95	8-23	41	5-03	65	7-06	62
6-20	10.9	6-03	132	8-24	41	5-04	87	7-07	62
6-22	10.4	6-04	156	8-25	41	5-05	95	7-08	62
6-23	9.6	6-06	184	8-26	41	5-06	95	7-09	62
6-24	9.3	6-07	194	8-27	41	5-07	103	7-10	58
7-12	4.7	6-08	179	8-28	41	5-08	146	7-11	58
		6-09	164	8-29	41	5-09	156	7-12	58
Station 7 (6850' Portal)		6-10	150	8-30	41	5-10	165	7-13	58
		6-11	141	8-31	38	5-11	156	7-21	58
8-02-74	17	6-12	133	9-01	38	5-12	146	7-22	58
8-11	25	6-13	128	9-02	38	5-13	137	7-23	58
		6-14	124	9-03	38	5-14	146	7-24	58

Date	Flow
Station 7 (6850' Portal)	
7-25-76[a]	58
7-26	58
7-27	55
7-28	55
7-29	55
7-30	55
7-31	55
8-01	55
8-02	52
8-03	52
8-04	52
8-05	52
8-06	52
8-07	52
8-08	49
8-09	49
8-10	49
8-11	49
8-12	49
8-13	45
8-14	45
8-15	45
8-16	45
8-17	45
8-18	45
8-19	45
8-20	45
8-21	42
8-22	42
8-23	42
8-24	39
8-26	39
8-27	34
8-28	34
8-29	31
8-30	31
8-31	31
9-01	31
9-02	28
9-03	28
9-04	26
9-05	26
9-06	26
9-07	23
9-08	23
9-09	23
Station 9 (St. Joe Shaft)	
8-11-74	0.2
8-18	0.2
8-25	0.2
11-02	0.4
6-03-75	21
6-04	21
6-06	21
6-07	21
6-10	21
6-11	8
6-12	6
6-13	7
Station 9 (St. Joe Portal)	
6-14-75	7
6-15	6
6-17	5
6-19	4
7-01	2
7-09	1
7-11	1
7-22	1
8-01	1
5-05-76	20
5-10	16
5-12	12
5-14	14
5-18	7
5-19	7
5-23	6
6-01	2
6-03	1
7-28	1
Station 10 (7100' Waste Pile)	
7-21-74	11
7-28	9
8-04	10
8-11	8
8-18	9
8-25	6
10-05	2
11-02	5
6-03-75	90
6-04	90
6-06	90
6-07	90
6-09	75
6-10	75
6-11	80
6-13	60
6-14	70
6-17	55
6-19	45
7-01	20
7-09	20
7-11	20
8-01	12
5-05-76	75
5-08	150
5-12	120
5-14	150
5-18	75
5-19	64
5-23	47
6-01	38
6-08	27
6-22	19
6-29	11
7-07	9
7-28	5
8-03	5
Station 10A (Meadow Creek)	
7-21-74	60
7-28	60
8-04	60
8-11	60
8-18	60
8-25	60
10-05	30
11-02	60
6-03-75	2570
6-04	1090
6-05	2670
6-06	2180
6-07	2180
6-09	930
6-10	870
6-11	1000
6-13	1230
6-14	1280
6-15	1430
6-17	1180
6-19	1330
6-20	1090
7-01	300
7-09	107
8-01	140
10-04	60
5-18-76	1650
5-19	970
5-23	1030
6-01	1100
6-29	215
7-07	190
7-28	120
8-03	120
Station 13 (Meadow Creek)	
5-20-76	315
5-21	630
5-24	850
5-25	1075
5-27	1120
5-29	1120
5-31	850
6-02	810
6-03	765
6-04	630
6-06	630
6-07	360
6-08	360
6-09	360
6-11	450
6-17	270
6-18	270
6-20	225
6-22	270
6-23	270
6-24	225
Station 15 (7400' Portal)	
7-21-74	8
7-28	6
8-04	5
8-11	6
8-18	8
8-25	3
11-02	5
6-20-75	14
7-01	18
7-09	16
7-11	16
7-16	12
7-22	12
8-01	11
4-13-76	4
4-19	6
4-22	0.5
4-29	18
5-05	20
5-10	40
5-12	29
5-14	48
6-01	29
6-25	29
6-29	14
7-28	9
8-03	10
Station 17 (F. S. Waste Pile)	
5-19-76	75
5-23	35
5-26	15
6-01	5
6-08	3
6-21	1

[a] Discharge is mean daily flow

Appendix III-3. Bucktail Creek drainage discharge data for 1974, 1975, and 1976. Discharge of all stations is given in gallons per minute (gpm).

Date	Flow
Station 19 (Bucktail Creek)	
7-21-74	5
7-28	4
8-04	5
8-11	4
8-18	4
8-25	3
11-02	1
6-13-75	30
6-19	20
7-01	10
7-11	7
8-01	5
8-08	5
5-24-76	77
6-02	21
6-08	13
6-22	9
6-29	6
7-01	6
7-13	5
7-23	5
7-28	4
8-03	4
Station 20 (7265' Portal)	
7-21-74	4
7-28	4
8-04	4
8-11	5
8-18	4
8-25	4
11-02	4
6-13-75	9
6-19	7
7-01	5
7-11	4
8-01	5
8-08	4
7-28-76	6
Station 21 (Bucktail Creek)	
7-21-74	10
7-28	9
8-04	8
8-11	6
8-18	6
8-25	7
6-18-75	45
6-19	40
7-01	20
7-11	11

Date	Flow
Station 21 (Bucktail Creek)	
7-26-75	9
8-01	10
8-08	9
8-14	8
5-24-76	75
5-25	157
6-02	49
6-08	29
6-22	24
6-29	14
7-01	15
7-08	12
7-14	10
7-21	10
7-23	10
7-28	11
8-03	11
Station 22 (7117' Portal)	
7-21-74	4
7-28	4
8-04	4
8-11	4
8-18	4
8-25	4
11-02	3
6-13-75	6
6-19	6
7-01	5
7-11	6
8-01	4
8-08	4
8-14	4
7-28-76	5
Station B1 (Bucktail Creek)	
7-26-75	12
8-01	13
8-08	12
8-12	11
8-14	10
7-01-76	22
7-08	21
7-14	15
7-23	14
7-29	15
8-03	13
Station B1A (Bucktail Creek)	
8-12-75	31

Date	Flow
Station B1A (Bucktail Creek)	
8-14-75	31
7-01-76	62
7-08	50
7-14	40
7-23	35
7-29	35
8-03	32
Station B2 (Bucktail Creek)	
7-26-75	49
8-01	53
8-08	43
8-12	43
8-14	31
7-01-76	73
7-08	60
7-14	49
7-23	33
7-29	43
8-03	43
Station B3 (Bucktail Creek)	
7-26-75	53
8-01	58
8-08	43
8-14	43
7-01-76	91
7-08	68
7-14	57
7-23	49
7-29	45
8-03	46
Station B4 (Bucktail Creek)	
7-26-75	69
8-01	58
8-08	58
8-14	49
7-01-76	105
7-08	84
7-14	66
7-23	57
7-29	55
8-03	50
Station B5 (Bucktail Creek)	
7-26-75	69
8-01	63

Appendix III-3. Continued

Date	Flow
Station B5 (Bucktail Creek)	
8-08	53
8-14	38
7-01-76	101
7-08	80
7-14	62
7-23	57
7-29	58
8-03	51
Station B6 (Bucktail Creek)	
8-01-75	0.5
Station B7 (Bucktail Creek)	
7-26-75	63
8-01	63
8-08	49
8-14	38
7-01-76	111
7-08	84
7-14	69
7-23	57
7-29	58
8-03	54
Station 23 (Bucktail Creek)	
7-21-74	50
7-28	30
8-04	30
8-11	30
8-18	20
8-25	30
11-02	18

Date	Flow
Station 23 (Bucktail Creek)	
6-13-75	273
6-18	314
6-19	240
6-20	236
7-01	141
7-11	80
7-24	58
7-26	49
8-01	58
8-08	49
8-14	43
5-25-76	435
6-02	225
6-08	165
6-22	110
7-01	100
7-08	77
7-14	62
7-21	63
7-23	54
7-29	51
8-03	49

Date	Flow
Station 6827 (Pierce Winze-6850' level)	
5-13-76	4
5-19	9
5-24	21
5-26	6
7-15	12
7-30	7
9-09	14
Station 68616 (616 raise on 6850' level)	
5-13-76	40
5-19	40
5-24	33
5-26	26
7-15	9
8-06	7
9-09	6

Appendix III-4. Water level data for piezometers installed in study area.

Date 1976	Depth to Water (feet)
Drill Hole 1	
6-08	2.78
6-21	3.06
6-29	3.11
7-01	3.16
7-07	3.25
7-12	3.29
7-20	3.25
7-27	3.34
8-03	3.35
8-06	3.44
8-09	3.43[a]
8-10	3.43[c]
8-12	3.44
Drill Hole 2	
5-21	11.25
5-22	40.50
5-23	50.02
5-24	57.35
5-25	60.73
6-21	64.57
6-29	63.91
7-07	64.08
7-13	64.03
7-20	64.00
7-27	64.13
8-03	64.14
8-06	63.86[a]
8-09	64.04[a]
8-10	64.07[c]
8-12	64.04
9-09	63.90

Date 1976	Depth to Water (feet)
Drill Hole 3S	
6-22	7.4
6-29	8.07
6-30	8.16
7-07	8.71
7-13	9.02
7-20	9.01
7-27	9.07
8-03	9.37
8-06	9.11
8-09	9.13[a]
8-12	9.21[b]
9-09	9.42
Drill Hole 3D	
6-22	8.60
6-29	9.17
6-30	8.99
7-07	9.02
7-13	9.84
7-20	9.83
7-27	9.96
8-03	10.12
8-06	10.01
8-09	10.05[a]
8-12	10.14[b]
9-09	10.44

Date 1976	Depth to Water (feet)
Drill Hole 4	
6-22	2.28
6-29	3.09
6-30	3.16
7-13	3.14
7-20	3.01
7-27	3.38
8-03	2.97
8-06	3.22
8-09	3.22
8-12	3.24[a]
9-09	3.30
Drill Hole 5	
7-01	83.84
7-07	84.36
7-13	84.30
7-20	84.25
7-27	84.20
8-03	84.30
8-06	84.29
8-09	84.28[a]
8-12	84.34[b]
9-09	84.48
Drill Hole 6	
6-15	34.90
6-22	34.17
6-25	35.20
6-29	35.25
7-01	35.26
7-08	35.30
7-13	35.33
7-20	35.39
7-27	35.44
8-03	35.46
8-06	35.47
8-09	35.50[a]
8-12	35.50[b]
9-09	35.66

a - Average of three measurements
b - Average of ten measurements
c - Average of nineteen measurements

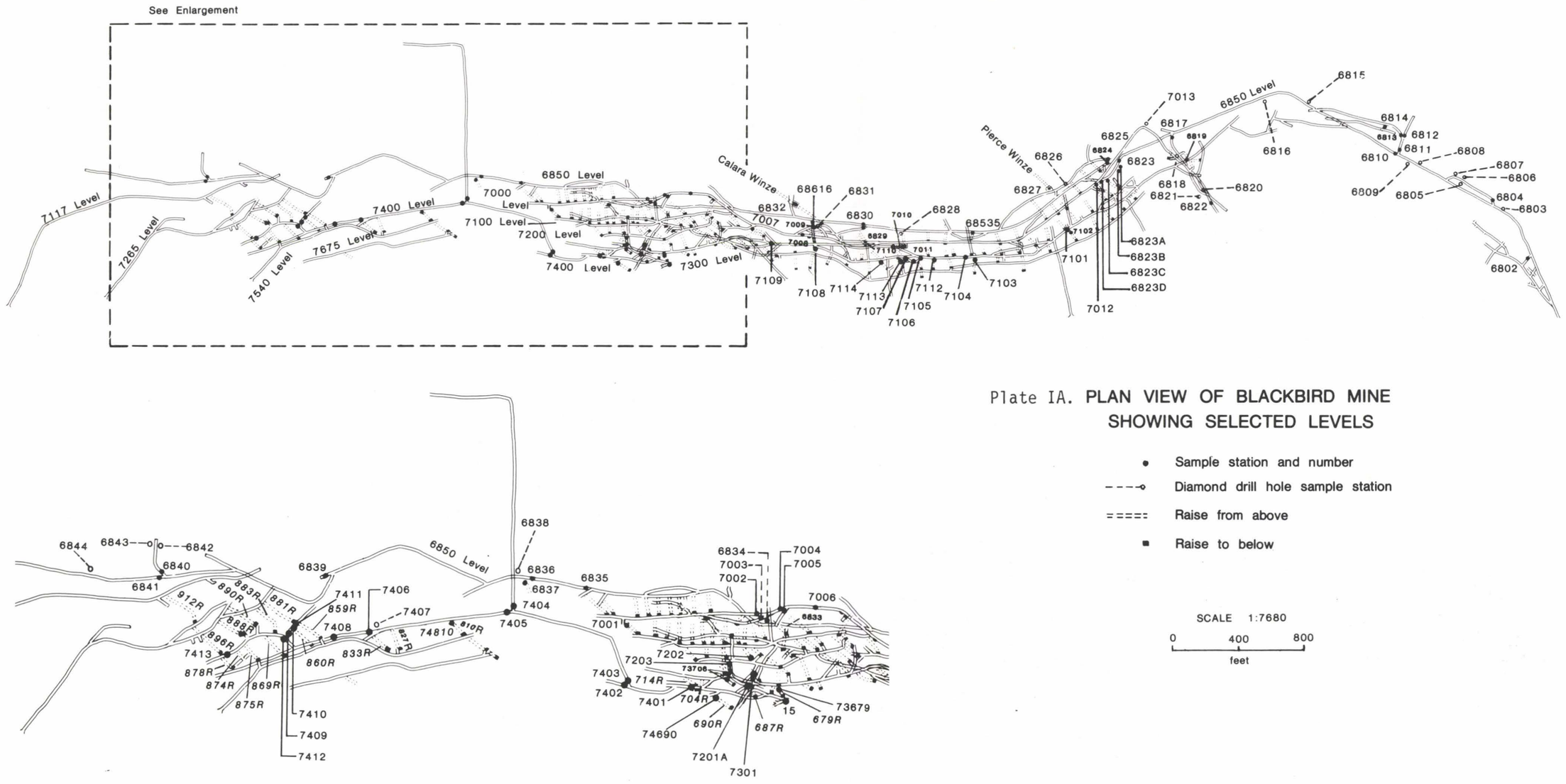

Plate IA. **PLAN VIEW OF BLACKBIRD MINE SHOWING SELECTED LEVELS**

- • Sample station and number
- ----o Diamond drill hole sample station
- ===== Raise from above
- ■ Raise to below

SCALE 1:7680

0 400 800

feet

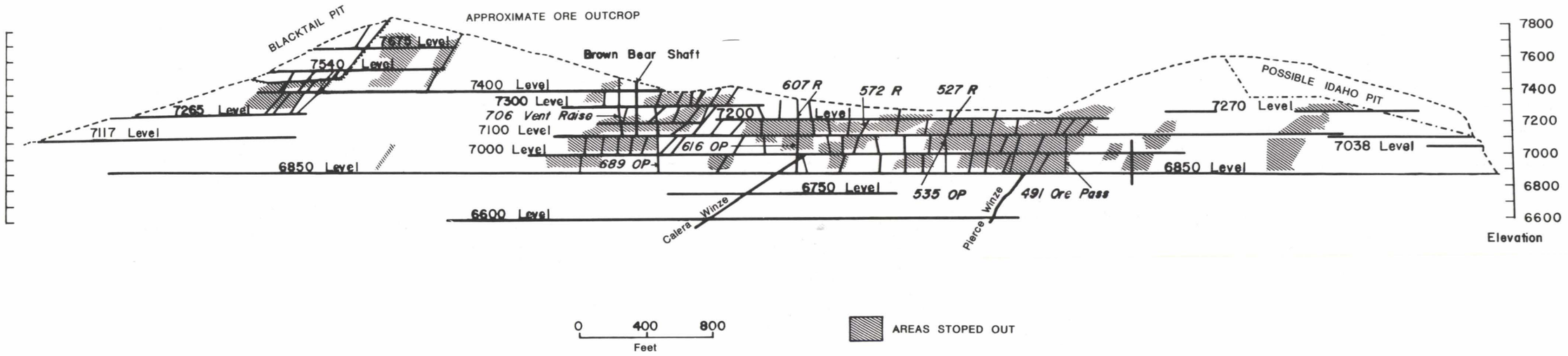

Plate IB. Cross sectional view of Blackbird Mine workings.

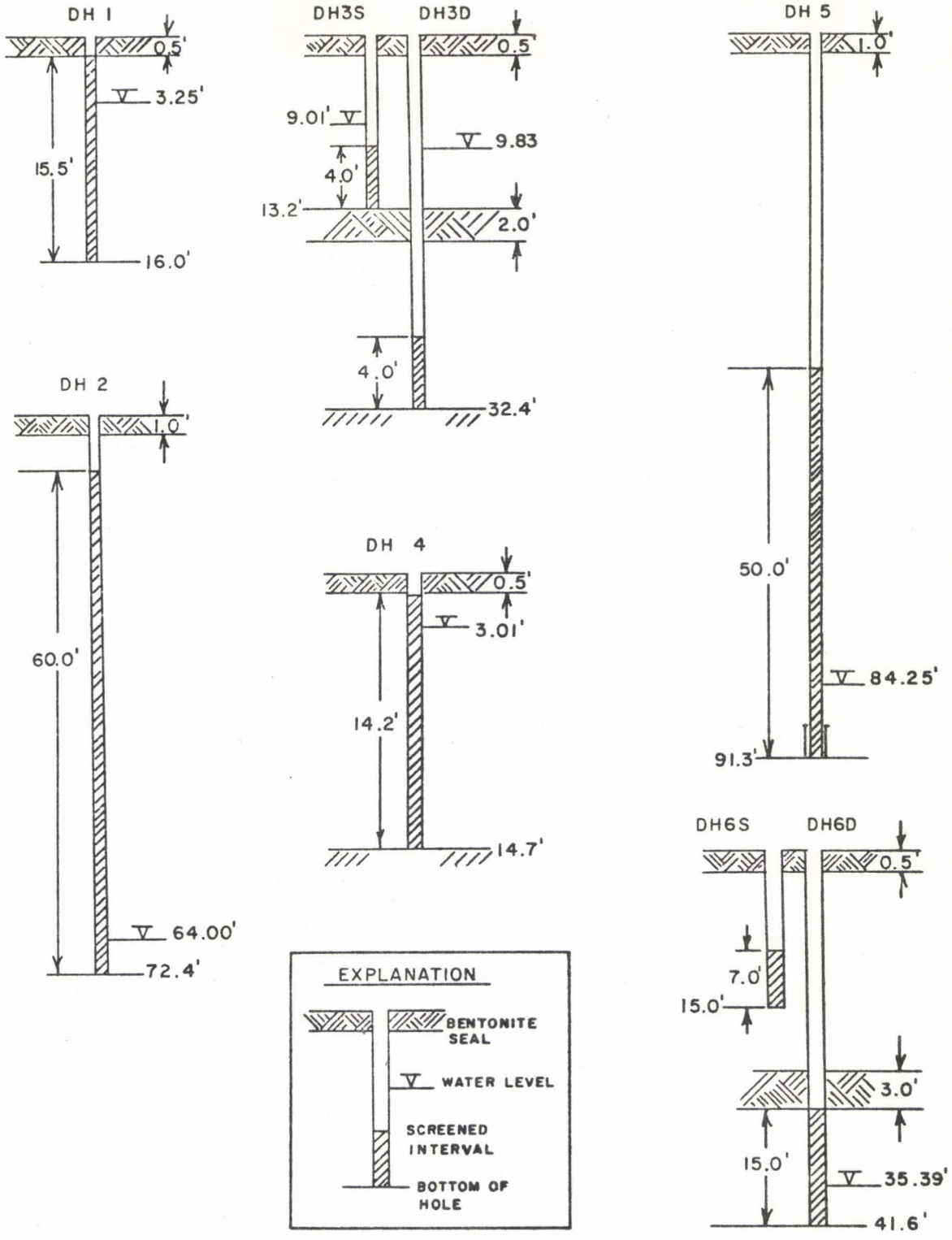

Plate II. Logs and construction details for piezometers installed in the Blackbird Mining area.